The A B C of Evolution

Joseph McCabe

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The
A B C of Evolution

By

Joseph McCabe

Author of "The Story of Evolution," "Evolution from Nebula to Man," "The Evolution of Mind," etc.

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PREFACE

During several years' experience of lecturing on Evolution I have been more and more impressed with the need of a new primer of the subject. The lecturer or writer on Evolution is too apt to think that the elementary stage is passed. This is a mistake. The field of science is now so large and so thoroughly cut up into distinct plots that a man or woman may have quite a good knowledge of one section, yet need elementary assistance on a general subject like Evolution. The man who could teach me much about wireless telegraphy or chemistry asks me for the plainest possible instruction on Evolution. Moreover, there are other things to study besides science. There are art, literature, history, and political economy. And for most people there is much work to do, and little time to study anything.

Hence I quite understand the demand for a very clear, elementary, and short text-book. There are several manuals in existence, and they have their merits; but they fail in one or other respect to meet the particular need I have in mind. Some are a little out of date. Some are too large. Some are not general enough. There is a large section of the public

that would like to have a quite modern and quite simple account of this wonderful thought which now runs through the whole of our culture. They want the A B C of the matter, but they want it up-to-date, so that they may understand what scientific men are talking about to-day. I trust that this little work will meet their wishes.

J. M.

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The A B C of Evolution

CHAPTER I

EVOLUTION THE KEY TO NATURE

If you want to understand what evolution is, and why some scientific men—who are not usually poetic—have compared it to a sun rising in the nineteenth century to illumine the darkness of nature, try to put yourself in the position of some thoughtful man of the days of George IV. There was already quite a respectable science in those days. There was a Royal Society. There were geologists and chemists and astronomers. For two hundred years Englishmen of great ability had been working hard to attain the kind of knowledge which we call "science"; that is to say, knowledge based as carefully as possible on actual observation.

Yet nature as a whole, and myriads of separate things in nature, were so dark and unintelligible that we may really say that they awaited the rising of the sun. Your grandfather, supposing that he were of a thoughtful turn, would ask endless questions to which

science could give no answer. Why had he this thin and useless coat of hair on his body? Why was his cat so like a tiger? Why did miners bring petrified fish-bones out of the deepest mines? Why was the negro black and the Chinaman yellow? Why was the moon cold, the sun hot, and the earth between the two? Why were Englishmen civilized and Africans not? Why had flowers different colours? Why was there such an immense variety of animals? Why were there tape-worms? Why had the shark no bones? Why was England an island? Why were there fiords in Norway?

You could fill an immense book with questions that could not be answered eighty years ago. And, apart from the fact that science was very young and needed more time, all these things were obscure, and threatened to remain obscure, because one single, simple idea had not yet been grasped. That idea was to be the starting point of the explanation of all these and hundreds of thousands of other problems. It was this: That nature, and all things in nature, had grown, during tens of millions of years, to be what they were. They had been shaped very slowly and gradually, and had passed through numerous earlier forms. They had been "evolved."

The word "evolution" is the Latin word for "unrolling." Roman books were written on parchment and rolled on wooden or ivory rods, as maps are to-day. Unrolling one, to read it, was "evolu-

tion." About the seventeenth century the word began to be used in English for the "unrolling" of the scroll of history, of the fates, etc.; then the unrolling or expanding of anything which had been, as it were, folded or rolled up. The body "evolved" from the germ. A nation, like the Romans, evolved from the pastoral tribe which history represented as its first stage.

This sort of evolution was going on so obviously all round our grandfathers that one may wonder why they did not perceive that it was a law of nature. For instance, one understood the striped pole outside the barber's shop because the modern barber was evolved from the barber-surgeon of the Middle Ages, who used to put this red pole, with a white bandaging tape wound round it, outside his shop to show that he bled people. One understood why a "gentleman" had two buttons on the back of his coat and the workman had not, because they were evolved from the mediæval gentleman, who buttoned his sword there, and the mediæval worker, who wore a smock, or at least had no sword. One understood the richness of the English language because it had grown out of a mixture of the tongues of the British, Anglo-Saxons, Danes, Normans, and other invaders. All history was really part of a science of evolution. All the political struggles of the time were processes of evolution. Every new machine, or fashion in dress, or improvement in the home, was an example of

evolution. Our fathers were painfully familiar with the use of weapons; and every museum put clearly before their eyes "the evolution of weapons."

It is clear to us now that they needed only to believe that everything had similarly grown, and they would find numbers of mysterious things lit up. If man had grown from a non-human type of animal, just as the modern Englishman had grown out of the Druidic Briton, it explained any number of puzzling features. If the flowers had grown to be what they are, and some had grown more rapidly than others, one understood the variety of nature. If the hills and fiords and valleys had been under the shaping forces of nature for hundreds of thousands of years, the face of the earth could be gradually explained. The English race, scattered over the world, was easily understood. It had a common root in mediæval England, and its later growth and dispersion might be read in history. Suppose that all the animals and plants of the world likewise had a common root, and had been growing and branching out, like a great oak, for millions of years! There was the great key: a key that would unlock the secrets of stars, and flowers, and oysters, and social forms.

It is hardly necessary to recall how it was that until recent times this simple fact was not appreciated. In many previous ages thoughtful men had drawn the natural conclusion that all the things in the world had grown. Numbers of the Greek

thinkers had said so. The chief Roman writer on nature, Lucretius, had repeated it. St. Augustine himself, in his best days, thought that all the different species of animals and plants had "grown" out of seeds that had been put in the earth at the beginning of time. The wonderful Italian monk of the Middle Ages, Giordano Bruno, taught evolution. But the fate of Bruno reminds us why it was that so few accepted the plain truth of evolution, which had been suggested by the Greeks 2,500 years ago. It was "heresy." All Europe was now convinced that sun and moon and stars, oak and lily and wheat, cat and bird and man, had been created as we know them.

With this belief science was bound to struggle. Scientific men naturally wanted scientific explanations of things, if it were possible. In a sense they wanted to conceive nature as a work of art: a statue that had been slowly carved out of a rude block, or a wonderful fabric that had been gradually woven on "the looms of time." If they could discover the chisels which had carved the statue, or the threads that had been blended in the fabric of nature, it was more intelligible. They very soon learned that nature *had* grown, during millions of years, to be what it is. The study of the rocks, which was very fairly advanced by the year 1840, was sufficient to prove this.

The rocks are the vaults of the great living family. When they were opened up, in the eighteenth and

nineteenth centuries, it was quite easy to see that burials had been going on for tens of millions of years. And it was noticed that the deeper you went the simpler the forms became and the more they approached each other. The facts themselves suggested that the animal-forms we know to-day, so different from each other as they are, had common ancestors in the past. Life was a great many-branched tree, with a single root in the soil of "dim, remote ages."

Several writers had suggested this before Charles Darwin became convinced of it in 1836, but that patient and gifted naturalist took twenty years to work out his theory and collect facts in support of it, so that his *Origin of Species*, which was published in 1859, was irresistible. One set of scientific men after another now began to apply the principle of evolution, or gradual growth, and each department of nature which they studied was lit up as it had never been before. Sir Isaac Newton had traced a remarkable unity in lifeless nature when he discovered the law of gravitation. A far more intimate unity was now discovered, both in living and lifeless nature, in the light of the new truth.

Everything known to us had been evolved. From distant suns to our social and religious institutions, from diamonds or oceans to the human struggles of to-day and the ideals of to-morrow, the whole contents of the known universe fell into one grand and intel-

ligible scheme. It was like looking down upon a hilly region in the early morning, when the summits of the hills stand out, far from each other, but a mist lies on the valleys and conceals the connections. Then the sun rises, and the entire panorama of hill and dale becomes a connected whole before your eyes. Merely recognizing the fact that nature had been evolved had that effect upon man's mental picture of it, or his "science" of it.

It is important to understand this clearly. The mind of man leaped forward, all the culture of the world advanced rapidly, when the *fact* of evolution was seen. But the *fact* of evolution is a different thing from the *methods* or *agencies* of evolution. Even if we knew nothing of the agencies which brought about evolution, the fact would remain a most important and permanent gain to every branch of knowledge. No scientific man in the world now doubts it, or has done so for several decades past. He would as soon think of doubting the existence of the sun. All the controversies which puzzle the reader of larger works on evolution relate to the agencies or machinery of evolution, not to the fact. To say that things "grow" is, of course, only a childish expression. When a geranium is "growing" in a pot there is a most wonderful machinery in it developing the stems and leaves and flowers. For the whole of nature the machinery is colossal, and it may be a long time before it is really known. I will

try to make it clearer that evolution is a great discovery in spite of all the disputes about its machinery.

Evolution is not a "force" or an agency that does things. Strictly speaking, "forces" and "laws" are not agencies that do things, though we often speak of them as if they were.[1] But evolution is not a force or energy; and it is a "law" only in the strict sense. It is an invariable *fact*. It is the fact of the unrolling of the scroll, not the hand that unrolls it. So there may be perfect certainty about the fact of evolution, and complete uncertainty about the machinery or agencies at work. Some say that, if this is so, evolution explains nothing. There could not be a greater mistake. It is literally true that the whole of nature is lit up when we recognize the fact that it was evolved. Any thoughtful person can see how intelligible man and his institutions become if we recognize that they were evolved. Hundreds of features which puzzled us before are now understood. This will become quite clear in the course of the book.

Now, Darwinism is not evolution. It is a theory of the way in which the evolution of living things was brought about: a theory of the machinery of a part of nature. Even if Darwin's theory comes to be rejected, his magnificent service in getting the fact of

[1] *Force* is an abstract word used in physics to express certain features of work or movement. It is matter or ether that really works. *Law*—a "law of nature"—is also an abstract word to express the fact that things do actually move or behave on certain definite lines.

evolution recognized makes him immortal in science. His theory is, as a matter of fact, very much disputed. Darwin looked about him, and saw that far more living things are born than nature can sustain or the earth hold. He saw that this caused a great "struggle for life," and that the "fittest"—those best equipped to meet their particular struggle—survived. Nature, in other words, "selected" the fittest; and so his theory is called "natural selection." Take the hawk. Its success in life depends on keenness of eye and strength of wing. Every time a few hawks are hatched some will have slightly better eyes or wings than others. They have more chance of surviving; and they will hand on their improved eyes and wings to the next generation. In the course of hundreds of thousands of years these minute improvements at each birth will have brought about a much higher type of bird. "Natural selection," he said, was the agency of evolution.

That this process does actually go on throughout nature, and even in our social and economic order, any person can see; but it is now disputed if it is the general machinery of evolution. The pioneer in any new field of research generally makes some mistakes. Some now think that the embryological machinery, not the destructive or "selective" work of nature, is the great agency. Some think that the gradual strengthening during a long period of small improvements in each generation is not a satisfactory explana-

tion. They believe that there are sometimes very marked advances at a single birth (which they call "mutations" = changes), and it is these which are the great agency of progress. So you get three chief types of theory, and, passing over other shades of opinion as unsuitable for this small work, we may express them thus:

1. *Darwinism.* Progress is due to the selection by nature of the fitter to survive. This really means the destruction by nature of the less fit to survive, so that strength, weapons, senses, etc., are gradually improved, just as we gradually improve our sheep and cattle. Few now hold that this is as complete an explanation as Darwin thought.

2. *Weismannism.* That the action of nature is secondary, and the advances of animals and plants are determined in the germ (or "germ-plasm"). Progress is gradual, by small improvements in each generation. This theory of Professor Weismann is not held as much as it was twenty years ago.

3. *Mutationism* or *Mendelism.* Small changes or improvements in offspring would be lost or "swamped." Large changes, in which the offspring differs considerably from the parent, often occur, and these make new species. This theory provides a very elaborate scheme of the elements of heredity. It takes its name from Abbot Mendel, but is chiefly due to Professor Hugo de Vries. It has to meet many difficulties, and is far from generally received.

CHAPTER II

THE EVOLUTION OF THE UNIVERSE

THE moment we begin to apply the principle of evolution we see the truth of the simple statements I have asked the reader to bear clearly in mind. The first is that the fact of evolution is the greatest discovery the mind of man ever made, no matter what controversies there may be about its machinery. The second is that Charles Darwin perceived a truth of the greatest importance when he discovered "natural selection." Even if you live in a village, you have only to open your eyes to see the reality of natural selection. You see the struggle of a litter of young pigs for food; the struggle of a swarm of grubs that hatch from a caterpillar's eggs; the struggle of men for employment, of shopkeepers for prosperity. The weakest, for the particular struggle, "go to the wall." The fittest, for the particular struggle (not necessarily the best or the strongest), survive. That is natural selection.

Now, this may not prove to be an explanation of everything in living nature. There are certainly many features of animals and plants that it does not easily explain. In any case, it does not go far enough,

because it throws no light on the living machinery (the embryonic machinery) which causes the variations at birth. Also, it may be true that new species are often formed by sudden, large changes at birth; though few instances of this are positively known. However that may be, Darwin pointed out a truth, and we now know that it was in some ways more far-reaching than he thought. He was a biologist, and was concerned only with living things. We know to-day that this truth more or less embraces the entire universe.

What we call the "universe" to-day is a collection of, perhaps, 2,000,000,000 suns or stars, to which our sun or star belongs. No one can possibly count them, as the greater part of them are represented only by very faint points of light on photographic plates which have been exposed for many hours in giant telescopes. They crowd together, making little clouds of light on the plates; and we can merely roughly estimate that there are about 2,000,000,000 of them in the system or collection to which our sun belongs. No doubt many of them have planets, as our sun has. No doubt there are living populations with ideas and institutions, on many of these planets. All these are contents of our universe. There are also incompletely developed stars, dead stars, and masses of loose material that may one day form stars. That is our universe.

I keep repeating the word "our" because it is

to-day an open question whether there are "other universes than ours." Many people think that the word "universe" means the "whole" of existing things, and the word is generally used in that sense outside of modern astronomy. But that is not the literal meaning of it,[1] and astronomers choose to call a vast collection of stars which form one immense family—that is to say, which control each other's movements by gravitation—a universe. There may be other great systems of stars which are so far from ours that they are practically independent. Many distinguished astronomers to-day think that we do dimly see such "island universes," as they call them, shining faintly, as blots of light, on the dark background of space. I will say more about this presently.

Our universe, then, is a collection of hundreds, and possibly thousands, of millions of worlds; if we call each star and its planets a world. They are separated by millions of miles of space from each other. They are stupendous globes of white-hot metal and gas, at a temperature of something between 3,000° C. (red stars) and 30,000° C. (bluish-white stars). Our sun, 860,000 miles in diameter, is a fair average, or a little above the average, in size, as far as we know. But some are so much more intense in their light that,

[1] The Latin Word "*universum*" is often said to mean "the unity of *all* things"; but it does not contain the word "all." It means a unified system.

whatever allowance we make for higher temperature, they must be far larger. We cannot measure the size of stars, but, when the distance is known, we can measure their brilliance. Professor Pickering has recently calculated that the star Rigel, in the constellation Orion, gives out 87,000 times as much light as our sun; and our sun has a temperature of 7,000° C. at its metallic surface, and possibly 1,000,000° C. in its interior. The star Canopus is said to be equal in light-power to 50,000 suns like ours.

Here we have a first suggestion of evolution in our universe. The colours of the stars may have various causes, but in the main they are determined by temperature. Some are blue, some white, some yellow (like our sun), and some red. That sounds like globes of metal cooling down; and the astronomer now has instruments by which he can fully confirm this first impression. The stars *are* masses of white-hot metal, surrounded by flaming gas, which rise up to a certain highest point of temperature (probably about 30,000° C. at the surface) and gradually cool down until they cease to give out light. By an instrument called the spectroscope—the most wonderful instrument ever invented by man—we can analyse their light and trace the different stages of their cooling.[1]

[1] I wish to be brief and simple here, but the reader who would like to know more about this fascinating branch of the science of evolution will find the material of this chapter, fully and clearly developed, in my recent work, *The End of the World* (Watts; 6s. 6d. net; with many illustrations).

The millions of stars in the sky are of different ages. Some are in the prime of life. Some (like our own) are beyond middle age. Large numbers—astronomers now generally hold—died long ago.

This is one half, the latter half, of the evolution of worlds. The next step is to trace the first half, to discover their origin and early stages. Here there is a good deal of dispute, but we may choose a very clear starting point which is admitted by all. If you leave your room full of fine dust at night, you will find all this gathered together on the floor in a layer the next morning. The floor (or the earth) "attracts" it, we say. Now, suppose an enormous cloud of this dust were in space, millions of miles away from any solid globe to attract it. Suppose this cloud were millions or billions of miles in extent, and it consisted of a mixture of particles of all the metals and gases. How would it behave?

We should say that if the dust were quite evenly distributed, and nothing entered it to disturb it, it might remain as a cloud for indefinite ages. But, as a matter of fact, the chances of such a cloud being quite equally distributed are very slight. There would be sure to be some parts denser than others. Then we know what would happen. These thicker parts or centres would begin to "attract" the dust from all round them. Even if there were no denser centres to begin with, there soon would be. As we

know from our shooting-stars, which are fragments of metal (from grains to large blocks) that shoot rapidly into our atmosphere at night, and are burned up by friction, space is far from empty. Countless myriads of these solid particles or blocks travel through it at a great speed. The "ocean of ether" is as full of them as the sea is of fishes. A great cloud of dust billions of miles in extent would capture countless numbers of them.

So there would be sure to be denser centres in our imaginary dust cloud. These would draw the surrounding dust by the same law of gravitation as the earth gathers the dust in your room. They would grow larger and denser. The spaces between the thick centres would grow thinner and thinner. Moreover, as these centres would be, so to speak, suspended in space, they would draw particles freely from all sides, and would take the shape of large loose globes. If you imagine this going on for millions of years, you see at once that in the end practically all the dust of the cloud will be gathered into so many large globes, with great empty spaces between them. You will also see that the heavier particles, the metals, will go to the centre, and the lighter particles, the gases, will remain at the fringe. You will have gaseous atmospheres round globes of metal.

The mathematician can tell us a good deal more about what would happen. We understand him well

enough when he says that this coming together, or condensation, of the particles of dust would cause heat. Compression always causes heat. And when you are thinking of a mass of metal dust weighing trillions of tons, as a star does, the heat will in the end be prodigious. The concentrated dust would become a star. We need only say further that these great centres of fiery concentrated dust would tend to turn round on their axes; and that, although they were tens of millions of miles apart, they would be sucked into each other and destroyed unless they travelled rapidly through space in orderly paths. At first, we suppose, they would be a disorderly crowd. Then "natural selection" would set in. The small irregular masses would be sucked into the larger. No doubt some of the giant suns I have mentioned have fed on others in this way. In the end the great cloud of dust would be a collection of fiery globes travelling in circular paths at a safe distance from each other.

That is how we understand the origin of stars. Such clouds do exist in the heavens in great numbers. Astronomers call them "nebulæ," which is the Latin for clouds. They already have heat enough to be visible to us. One large class of them, which we call the "spiral nebulæ," are much disputed. Some think that, as I said on an earlier page, they are separate universes at a prodigious distance from us. I do not share this view. Most astronomers believe

that the spiral nebulæ are masses of glowing metal being formed into worlds. They are nebulæ in an advanced stage of evolution. Other nebulæ are plainly proved by the spectroscope to be clouds of billions of miles of glowing gas. At all events, our "cloud" is not an imaginary thing at all. Turn it into the Latin "nebula," and there are about 200,000 of them known to us.

Apart from a few recent speculations, which do not seem likely to be accepted, the general belief is that the stars were made by the gathering together into solid globes of vast loose clouds of material in this way. Whether the material was gas, or solid particles, or both mixed together, is disputed; and we need not go into the point.[1] How far metals like radium add to their heat is also disputed. These things must be studied in larger books. The general truth is enough here. The stars are evolved from great clouds of loose matter by condensation.

Sometimes you read in the papers that a "new star" has appeared in the heavens. It is not thought that this is the ordinary birth of stars. They grow, and die down, too rapidly. The life of a star,

[1] Some may care to have a word on these disputes. There are three chief theories. The *Nebular Hypothesis* conceives the cloud as mainly of gas. The *Meteoritic Hypothesis* thinks the starting point was an immense swarm of meteors. The *Plantesimal Hypothesis* takes as its starting point a vast cloud of solid particles, and these are supposed to have come from the ripping open (by another star) of a dead sun.

normally, must be hundreds, if not thousands, of millions of years. Of course, the great sudden blaze which we call a new star is a blaze of white-hot gas; not the star itself. Still, these things seem to be "accidents." A few think that two stars have come into partial collision—"grazed" each other, so to say. If two masses of metal, each weighing trillions of tons and travelling at a hundred or more miles a second, were to do this, we would certainly expect a terrific "blaze." But collisions must be very rare, and new stars are frequent. Probably a dead or invisible star has rushed into one of the great dust clouds (nebulæ) and been raised to white heat, in part, by friction. Whatever be the real explanation, the fact is impressive. The millions of stars of our universe are living, dying, and being born again all round us.

Modern science goes a step further than this. Here I am going to say something which is by no means settled, but the speculation is so vast and interesting, and gives such a wonderful unity to the evolution of the universe, that it cannot be omitted.

Everybody now knows that a mysterious something called "ether" runs from end to end of the universe, and passes *through* the most solid matter that we know. The stars are like great sponges in an ocean of ether. It contains those other "island-universes" (if they are such) of which I spoke, as

well as ours, or else their light would not reach us. What if all our stars and planets and nebulæ—all the matter of the universe—were evolved out of this ether! Clearly this is one of the greatest and most comprehensive ideas that physical science ever gave to man.

There is now very strong reason to believe this. Since the discovery of radium, and all the other discoveries to which this led, our scientific men are convinced that the atom of matter is built of very minute centres of energy in ether (electrons). The simplest atom may contain more than a thousand of them, whirling round at speeds approaching 100,000 miles a second. The atoms of the heavier metals contain hundreds of thousands of them. The atoms are orderly "systems" of electrons, just as universes are orderly systems of stars. And it is probable that natural selection has been at work in checking the evolution of both systems: the one, the atom, so small that trillions would go into a pin's head; the other, the universe, thousands of billions of miles in extent.

Here, then, we have the answer to the last question: Where did the matter which makes the stars come from? Apparently from ether. Where did the ether come from? We have no reason to suppose that it came from anywhere. It may be the fundamental reality, from the bosom of which matter rises, to form stars which glow for hundreds

of millions of years and then die, to be born and glow again.[1]

[1] What about Einstein's theory, which, some tell you, does not admit ether? As a matter of fact, it admits a different kind of ether, in which light does not travel in straight lines, and it gives a new idea of gravitation. Einstein's theory cannot be popularly explained, as every scientist who has tried to do it admits. The best attempts are an article by Sir Oliver Lodge in the *Nineteenth Century*, December, 1919, and an article by Professor Eddington in the *Contemporary Review* for the same month. It is a matter of the highest mathematics, and, even if it were ever proved (which is doubtful), it will not modify the ordinary teaching of science as much as some say.

CHAPTER III

LIFE IN THE PRIMITIVE OCEAN

FROM this broad picture of the universe we must now come down to our little earth, and study the evolution of life on it. There used to be writers who told us how we were "dwarfed" by the vastness of the universe. It really makes no difference whatever to us how vast the universe is. We remain just the same size, however much the universe grows. Then there were writers who tried to console us by saying that probably we were the only living inhabitants of the universe. No man of science would now entertain that. We cannot prove that there is life anywhere except on the earth; but we will study the development of the earth and the life on it, and we shall realize that the same thing has probably happened in countless parts of the universe.

I spoke of a great dust cloud which might condense into patches, and these in turn into stars. Now, in each patch, or region of concentration, there are sure to be irregularities. Some parts will be denser than others. The dust will, therefore, not *all* be drawn to the central part. Some will gather round the other denser centres. In other words, the last result will

be a great central globe and a number of smaller globes (or planets) connected with it.

These smaller globes would, of course, be sucked by gravitation into the central globe unless they moved round it at a great speed. There are several ways in science of showing how this circulation of the planets round the sun might be caused, but they are too advanced for this little primer. If the reader will look at the photograph of a spiral nebula in some astronomical book, he will see the fiery matter condensing into a large central sun and a large number of smaller fiery masses all round it. We know that they are moving round it. The whole structure is turning round.

But how do the planets come to follow orderly paths round the central sun, at such distances and such speeds that the system may last for millions of years? Natural selection gives the answer. At first there were probably far more planets circling round our sun than there are now. Those which followed unsuitable paths were drawn in by the others or by the sun until only the "fittest" survived. Our eight planets are the survivors of a mighty struggle for life.

We have every reason to suppose that the other stars were formed in the same general way as our sun. It is therefore probable that they have, unless there were special conditions, planets of their own. These planets are made of the same material as ours. The spectroscope can tell us what even the most

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distant star in the universe is made of, and it reports to us that much the same material is found throughout the whole universe, and even in the universes beyond (if there are any). When you have the same material, following the same general laws, you naturally expect results of substantially the same nature. The metals would keep to the centre, and form solid globes. The free gases would remain at the fringe, and form atmospheres and oceans. This is the reason why men of science regard it as highly probable that there are countless planets with living populations. We have no reason to suppose that our earth was made in any special manner. There are probably globes in all parts of the universe with the same conditions of life: chemicals, air, water, and a certain temperature.

But we must study the making of our earth a little more closely. Originally, as I said, it was one of many fiery globes which circled round the sun. They gradually cooled. The planet Mars, being very much smaller than the earth, cooled before it. That is why we suppose that, if there is life on Mars (we are not quite sure of its conditions), it began before life on the earth, and is probably more advanced. However, our earth gradually cooled, and at length the oxygen and hydrogen gases in its atmosphere were able to unite and form water. But the earth was still red-hot. Water could not settle on its surface. So the whole mass of water which now forms our oceans then

existed in a state of cloud or steam in the atmosphere. The earth was still a fiery metal globe, surrounded by a tremendous shell or mantle of steam. That is how we find the planets Jupiter and Saturn to-day. They are so large that they have not cooled down as far as the earth. They are red-hot at the surface, and all that we see of them is the great mantle of cloud or steam that surrounds them. You see, every feature of our solar system is just as we should expect to find it on the theory of evolution which I gave in the last chapter.

Under a great canopy of moisture like this, the metal surface of the earth might remain molten until it sank to about 800° C.; but its heat was being discharged into space all the time, and its temperature sank steadily. It was, remember, a block of iron cooling down; or, rather, it was a mass of *molten* iron, like the liquid, glowing stuff you may have seen in a furnace. As the temperature sank the steam would approach closer to the surface, and at last would be able to settle as water. This would, of course, take a long time. At first the water would boil, and be blown back in the form of steam. This, however, would hasten the cooling of the earth, and the time soon came when the surface of the globe was covered with a boiling ocean. It was not at first salt water. The salts of the sea have been gradually washed out of the rocks. But as the primitive atmosphere was very far from pure, the waters which settled

on the earth would also contain great quantities of acids and chemicals.

Here, then, we have three features of the earth explained: its molten interior, its solid crust, and its oceans.[1] A globe of molten metal naturally cools first at its surface, and forms a crust or "slag," as molten iron does in the foundry. It is now at least a hundred million years, and may be very much more, since the earth began to cool. The solid crust has become from fifty to seventy-five miles in thickness, and the great mass inside remains at a terrific temperature. The pressure is too great to allow it to be fluid, but there are leaks and irregularities in the crust, and at times it oozes through as white-hot lava. There you have the explanation of volcanoes, and partly of earthquakes.

At first the crust would be a fairly equal scum or slag all round the globe, and the ocean would be fairly equally distributed over it. At the most a few ridges of land might peep out of the hot ocean. But there would be for ages, probably for millions of years, a mighty battle between the crust and the molten matter below it. In cooling, the surface or crust would naturally shrink. The skin, so to say, would always tend to be too small for the globe, and

[1] I ought to warn the reader that many geologists now follow the *Planetesimal Hypothesis*, which I mentioned on p. 16. According to this, the earth was formed with less heat, and was never all molten. The account I am following is the one generally received, and most probably correct.

would burst. Then the molten masses below would pour up and over the crust. This would go on for long ages, until the crust was thick enough to confine the fiery giant below it. That is why we find the earliest rocks, which represent half the life of the earth, mainly volcanic. When the crust had set firm, the great process of wearing down the rocks would start, and the sand and fragments would begin to form our "sedimentary" rocks at the bottom of the sea.

After these great upheavals the crust of the earth would no longer be fairly even. There would be hills and ridges, with corresponding valleys and depressions. The waters would settle in the depressions, and the division of "dry" land and water would commence. As the crust became thicker and more irregular, great masses of it might be undermined by water, far below, and sink or "subside," making mighty hollows in the surface of the earth. Probably our ocean-beds were formed in this way. It drained the shallow seas off the rest of the crust, and made more "dry" land. The land, in other words, has been gaining on the water all through the history of the earth. There was very little dry land at first, and there were no mountains. There is more dry land than ever to-day.

This may seem to you to be not a very important matter to dwell up n, when I have, for reasons of space, to omit thousands of interesting features. On

the contrary, it is *most* important. What I want especially to give in this little work is the general machinery of evolution, the broad principles of the subject. And this constant change of land and water is a most important part of the machinery of the evolution of life. You might poetically imagine it as the struggle of the land to free itself from the water. In the course of time it has thrown the bulk of the waters into deep ocean beds, and has reared itself in high mountain-chains and broad continents. The changes which this restless struggle has brought about from age to age have very deeply influenced the development of life, as we shall see.

But first we have to introduce life itself. It appeared at a very remote date in the warm, shallow ocean of the primitive earth. How long ago that was we cannot say. Most geologists would say between fifty and a hundred million years ago. There is, however, a new school which professes that what are called the "radio-active" minerals (minerals whose atoms break up, like those of radium) in the older rocks show that the earth must be more than a thousand million years old. There is really no reason why we should be in a hurry to decide how old the earth is. It is enough that the story of life on it began at least tens of millions of years ago.

Where did the first living things come from, and what were they like? That is a more interesting question. Unfortunately, science is not yet able to

give a confident answer. This is hardly surprising. Man is at least half a million years old, but science is only about two centuries old; and to expect it to take a very wonderful and complex change that occurred a hundred million years ago and tell us confidently "all about it" is to expect too much. We can only speculate, and there are two chief lines of speculation.

It must be quite understood that every scientific authority in the world now believes that life was naturally evolved from the chemicals of the early earth. Everything that we *can* satisfactorily study was evolved. We have therefore a right to assume that all things were evolved, unless such a natural evolution is in any particular case shown to be impossible. No one has ever shown that the natural evolution of the first living things is impossible, or even improbable, so we take it for granted. That is perfectly sound logic as well as sound science. There is one distinguished scientist, Professor Arrhenius, who thinks that the germs of life came to us from another planet. That is not only difficult to imagine, but it only puts the problem on the shelf instead of solving it. Life was naturally born in the shallow oceans of our early earth.

There are many theories of how it was born, and I would recommend the reader who wants to examine them to try to see a valuable work by a group of American professors, called *The Evolution of the Earth*

and Its Inhabitants (1918). In a chapter on "The Origin of Life" Professor Woodruff gives all the theories. You need a good knowledge of chemistry to understand them fully, and I need only say here that both chemists and biologists agree that a natural chemical evolution could produce the first living things. But you must be careful not to suppose that even the lowest living things in nature to-day—say, the simplest bacteria—were directly evolved out of inorganic matter. A very long evolution, with thousands of phases, would be required. It would take ages. First the stuff of which living things are made, protoplasm, would have to be formed by a long series of chemical changes and combinations. Then this stuff would have to break up into the distinct units which we call "cells"; for each of the simplest animals and plants is a single cell.

When I spoke of "two chief lines of speculation," I meant that you may suppose that the natural development of life—what used to be called "spontaneous generation"—is going on *now* in nature, or that it only occurred under the very special conditions of the early earth. Both these views are held by distinguished biologists. Professor Benjamin Moore has an excellent little work on the former line—that life is still being evolved in nature—in the "Home University Library." It is called *The Origin and Nature of Life* (1912). He and other eminent authorities (such as Professor Thomson, of Aberdeen)

believe that what many call the "mystery" of the origin of life is really an ordinary event in nature's life to-day. It would be below the level of the microscope, so that the old controversy about "spontaneous generation" does not settle the question. Other scientific men, perhaps the majority, believe that it was the very extraordinary conditions of the early earth which begot life. The temperature of the ocean was very high, the chemical conditions are unknown to us, the electrical conditions were more pronounced than now, and there may have been a good deal of radio-activity. It seems more probable that the evolution of life was due to these special conditions, which have passed away for ever.

It is hardly necessary to point out that much the same conditions would be found at one time or other on all the planets in the universe of any size. They are globes of (generally) the same material as ours, cooling down. That is why we expect life in myriads of other places besides the earth. And as we saw that other stars are older than ours, and some have actually run their course and died, it seems likely that the full story of life had been played out on countless globes before man began his career on earth.

Well, we return to the first living inhabitants of the earth, which must have been far simpler than the lowest bacteria that we know. In fact, it would be correct to say that there were no "first" living things. Inorganic matter slowly developed into organic, and

this was slowly shaped into living units. This particular evolution must have taken ages. There was no more a "first" living thing than there was a "first" man. Many difficulties will be avoided if we bear in mind the extremely slow and gradual nature of these evolutions.

The next great point was the division of early life into plant and animal. There is really no essential difference between the two. They are made of, substantially, the same plasm, and in the lower circles of life to-day it is often impossible to say whether a living thing is a plant or an animal. But some of the early inhabitants continued to feed on inorganic matter—the chemicals in the soil—and this is mainly what we mean by a "plant" of vegetal organism. As the soil holds the chemicals they need practically everywhere, they do not, as a rule, require locomotive organs. They "take root." And as sensitiveness is of no use to stationary beings, they do not develop sense organs. Thus you get the evolution of a plant-world. The earliest, of course, floated in the water; but some took root in the soil at the bottom of the ocean, and in time great thickets of giant sea-weeds arose. We will trace these to the land in the next chapter.

Some of the early living things formed the habit of devouring their neighbours, instead of building up plasm out of inorganic matter. This is the beginning of the animal. It is quite plain that this means a

precisely opposite development from that of the plant. It means "hunting"; so the hunter and the hunted develop, very gradually, organs of locomotion, sense-spots, mouths, stomachs, weapons, armour, etc. Even in the microscopic life of the pond, where every organism is still a single cell, you get bewildering variety of developments of this kind. But we cannot linger here over this stage.

In time the cells cling together, and larger animals ("many-celled") are formed. This affords a better opportunity for specializing. Some cells become muscle-cells, some nerve-cells, some stomach-cells, some weapon-cells, and so on. You can see all this in a primitive way, under the microscope, in the common pond hydra. The jelly-fish or the anemone you find at the coast are advances of the same type. The animals grow larger and larger, and the development of their separate parts increases. Eyes and other senses begin as little pits in the skin lined with sensitive cells, and slowly improve. After a time (in lowly worms) these are connected with each other and with a group of nerve-cells in the head: the primitive brain.

What I have described in the last four paragraphs certainly took millions of years, and probably tens of millions of years! During all that time animals were soft-bodied, and have left no "fossils." It is by studying them in nature to-day that we trace the lines of their evolution. But at last animals with

hard parts were developed, and we begin to find these preserved as fossils in the rocks. Some began to form coats of lime (shells), and the great family of the Molluscs (mussels, cockles, oysters, etc.) spread over the floor of the ocean. Natural selection is very useful in explaining protective parts of this kind. Others had their bodies drawn out into sections, with a tough coat on each section (crabs, water-fleas, shrimps, etc.). Others had long wriggling bodies (worms). The seas now teemed with life, and there was a mighty struggle for food and safety. The less fit perished, age by age. Organization crept higher and higher.

But I will close this chapter with an illustration of the way in which the geological changes which were going on all the time influenced the living things, even in the water. I have said that the land was rising above the water, as the ocean sank into deeper beds. We have strong reason to think that these changes were often acute and violent. The man who says that the secret of progress is "evolution, not revolution," may be talking very good social philosophy—I have nothing to do with that—but he is not talking science, as he thinks. In every modern geological work you read of periodical "revolutions" in the story of the earth, and these were the great ages of progress—and, I ought to add, of colossal annihilation of the less fit.

We will see some of these later. Here I refer to

one which occurred at the period we have reached. There were violent changes of land and water. Great continents, which had for ages spread out very flat and swampy, were tilted. Mountain-chains arose, with mountain torrents. The rivers, which had been sluggish for ages, became far swifter. This meant a great change for the swimming population. Already the hunt for food and escape was developing swifter means of locomotion. Now the water itself would wash them away if they did not develop more power and speed. No doubt whole vast populations of floating and swimming things perished, and the speed of others was more rapidly developed.

At the close of these great changes the fish, the king of the early ocean, appears. You see how beautifully his long boat-like body, his powerful fins, his eyes and nose and mouth and teeth at the fore-end, respond to the new conditions. They were the outcome of a very long and hard struggle. And the same geological changes which brought about, or hastened, this struggle and new "adaptation" are now going to open a new and most important chapter for us.

CHAPTER IV

LAND LIFE BEGINS

More than half the story of life was over at the time of the appearance of the fish, which we have reached. That half of the story is not only very imperfectly known to us, but it is difficult for people who have not a fair knowledge of science to follow it. I have therefore dealt with it on *very* broad lines. Those who wish to know more may consult my larger work, *The Story of Evolution*, in which the development of each branch of the lower animal world is fairly traced. The second half of the story of life, mainly of life on land, I will now tell more in detail. It is easier to follow, and it will illustrate every principle of evolution.

First, then, you must begin by thoroughly grasping the immense influence of environment on the evolution of living things. There is a warm controversy in modern science as to the respective shares of environment (surroundings, climate, etc.) and heredity. If you read some of our English writers, often men of distinction in science, you will get the impression that it is old-fashioned to talk about the influence of environment; that all changes and ad-

vances are caused and settled in the germ-plasm (the seed). Do not believe it. The science of heredity is still very obscure and imperfect, so I am saying little about the *internal* causes of those changes in animals and plants which make evolution possible. They are of the very first importance, but are still obscure. What is clear is that the changes in the earth itself have had enormous influence in directing these variations at birth into the formation of new species.

Here we have a striking illustration. The land rises, the rivers flow more rapidly, and the need for speed, which was already great on account of the struggle of hunter and hunted, becomes greater than ever. The fish family appears in the waters, beginning with uncouth forms that no longer exist, passing on to the shark, then branching rapidly into hundreds of types. The fins were probably at first folds of the skin, which were gradually strengthened by ribs of cartilage. Bones were not yet developed. The lower fishes of to-day (sharks, rays, etc.) have no bones. They are the survivors of one of the earliest families. The backbone is the chief new departure. The great "back-boned" (vertebrate) family has begun. But the backbone was at first not a bone at all. It was just a stiffening rod of cartilage, and its evolution is easily traced.

We must turn now to another momentous consequence of the geological changes which I have

described. It is useful to try to picture this early earth on which a new act of the drama of life was opening. There was little solid land. A warm ocean rolled over the greater part of the surface of the globe, and in it the story of life had so far proceeded. The atmosphere was foul and thick, quite unsuitable for such land animals as we know, and generally saturated with moisture. The enormous quantities of carbon and moisture in it let only a sombre light of the sun pierce through; but, on the other hand, they prevented the heat from being freely reflected back into space, and an almost tropical climate existed all over the earth. There was no winter season. Frost and snow were unknown anywhere.

The land now began to gain on the water. Ridges of hill no doubt arose, but most of the new "dry" land would be broad swamp and mud-flat. Upon these shores life began to crawl from the overcrowded ocean. Plants must have led the way, since animals would need them for food. We know that the conditions—steamy swamps and an atmosphere rich in carbon—were good for such types of vegetation as there were at the time, and as they became adapted to land life, or swamp life, they throve and evolved. Low types of ferns and mosses appeared, and in the rich, warm, low-lying earth they found a golden age. As time went on they grew to gigantic proportions. Most of them are now extinct, but the little "mare's tail" which you find beside a stream to-day had a

cousin among the early plants. It grew to a height of forty or fifty feet, ordinarily, and sometimes to nearly a hundred feet! It was an age of giants. Club mosses ran to a height of a hundred and fifty feet; and even tree ferns sometimes spread their graceful dark green canopies at fifty or sixty feet above the soil.

The animals had meantime followed the vegetation. Their skeletons or shells are now buried in the soil, which has become our rocks, and we can fairly trace the invasions from the sea. Snails were among the earliest arrivals. Worms of various kinds became adapted to land life. Presently we find traces of insects—"primitive bugs" and "primitive cockroaches," to translate the learned names which are given to them. There is in South America and a few other places to-day a very primitive little creature, called the Peripatus, which you would take to be a very strange caterpillar if you met it in the wood. It is one of the beings of the remote past, which has somehow survived the struggle of ages, and it helps us to understand the origin of the insects. Apparently some of the worm-like creatures which invaded the land from the sea developed tubes in the skin (a sort of tiny "lungs") for breathing air. They flourished, and, as is almost always the case with these large prosperous families, they scattered and evolved in various directions. From them, we think, in the course of time, came our insects, spiders, scorpions,

and centipedes. All these developed gradually in the age I am discussing.

But I am hurrying over these lowly creatures in order to give more time to a more important invader of the land. This was the fish. You may think it easy enough to imagine snails and worms being adapted to life on land, but the idea of a branch of the fishes leaving the water and becoming land animals must seem strange to those who have not a good knowledge of natural history. If it be clearly understood that, as I have so often said, these changes and adaptations to a new life were very slow and gradual, the difficulty lessens. But it disappears altogether when you take a good work on natural history and zoology, and read what the author has to say about "lung-fishes."

He will tell you that in certain rivers of Queensland there are short, stumpy fishes which have *a lung* as well as gills. The water of those rivers runs low in the summer, and the lung then comes into play to help out the animal's breathing. You will next learn that in certain rivers of Egypt and of South America there are fishes of the same family with *two lungs* (like ourselves) as well as gills. The rivers in which they live dry up entirely in the summer. The gills (for breathing in water) are then useless. The fishes bury themselves in the dry mud, and breathe by their lungs until the waters flow once more. They can walk on their fins; and, in fact, the fins of some

of them are more like slender and badly-made limbs than fins. So here is "a fish out of water" that is not less comfortable than in water. It is the first amphibian; a connecting link between life in water and on land.

But were there such fishes in the remote age which we are considering? We have only to compare the fossil remains of certain fishes belonging to that age with the skeletons of our lung-fishes, and we know that there were. These fishes are survivors of a great family of lung-fishes of early times; and as we find them so far apart as Queensland, Egypt, and Brazil, it seems that this family must at one time have been spread over the entire earth. Some branch of the family, or some branch of the fish-world closely related to them, left the primitive waters and began the important story of the evolution of the quadrupeds. We are not quite sure from which branch of the ancient fishes the quadrupeds came. If it was not the lung-fishes themselves, it was some common ancestor of the lung-fishes and another group.

Let us come back for a moment to the gradual rise of the land. It meant that enormous shallow seas which had become densely peopled with fishes now disappeared. It meant swifter and narrower rivers. It meant less lakes and lagoons. It meant more circulation of the moisture in the atmosphere. These are the things to study, not dreamy speculations such as you find in Professor Bergson, if you want to

understand the evolution of life. The decreasing lakes and rivers and shallow seas were overcrowded. There was a fearful fight for oxygen and for food. For those which ventured back into the deep seas there were sharks thirty feet long, with teeth five inches long, and other great fishes with jaws two feet in width, waiting. There was, in a sense, a race for the land—that is to say, an increased development of adaptation to land life. Lungs for breathing air were the chief things required; and we find lungs (or other air-breathing organs) developing on all sides. The fish would develop its lungs out of the "floating bladder," or gas-bag, which it already had for swimming purposes. In some fishes this bladder is double, and is already connected with the gullet by tubes.

Naturally, I can give here only a very superficial account of what happened, but all the details of the change to land life will be found worked out in larger scientific works. For my purpose it is enough to describe how, at the time when the primitive ferns and mosses spread over the warm earth (in what a geologist calls the "Devonian Period," because its most characteristic rocks are those red sandstone cliffs you may have seen in Devonshire), a great swarm of uncouth lung-breathing fishes covered the land. No doubt they "kept one leg in the water," so to say. They preferred to live in water as far as they could. But there was a desperate struggle for food in the crowded waters, while the land had as yet

no other large animals on it, and was becoming rich in insect food. As these lung-fishes lived more and more on land, walking on their fins, the broad paddle of the fin was slowly converted into a strong and flexible bony stem—the leg. These ancestral quadrupeds had at first two pairs of fins, as some fishes have to-day. The two pairs of fins gradually became legs, with five toes (made out of five rays of the fin) at the end. The lungs continued to improve. The amphibian—father of our frogs and newts—made his appearance. The quadruped race was born.

Let us glance again at the vegetation. I have said that there was no cold or winter anywhere on the earth. We know this because the fossil plants we find are all of a semi-tropical character. As there was thus no winter chill, the plants throve luxuriously, from pole to pole, all the year round. The whole earth was semi-tropical in temperature, and most of it was very damp, low-lying, steamy. This suits ferns and mosses, and they, as I said, grew to gigantic sizes. It suited them also that the air was rich in carbon, and with all these favourable conditions the plants of the time grew denser and denser. This period of "perpetual summer" lasted millions of years, and we are not surprised to learn that before the close of it the earth was covered with such forests as have never been seen since.

Here another interesting question has been answered by the story of evolution. By the beginning of the

nineteenth century it was well known that there were great seams of coal in the crust of the earth, and it did not take long to discover that these seams are the decomposed remains of extraordinary forests which at one time covered the earth. The tree trunks and fern leaves are often quite plain in the coal. But they all belonged to one particular and remote period (the Carboniferous, or Coal-bearing, period) in the story of the earth. Why had there been such vast and unique forests at that period? I have given the answer. The conditions were unique for that kind of vegetation. It was the golden age of ferns and mosses and similar types. It has given us the coal seams of the world.

How and why the great forests came to an end, and have never re-appeared, we shall see in the next chapter. Let us look more closely at them before they pass away. On the west coast of New Zealand I have looked down, from the summit of the hills a mile or two inland, upon forests of tree ferns spreading above a great carpet of every variety of mosses. This is a degenerate patch of the great coal forests of long ago. It has no longer the luxurious conditions of the coal forest. The winter there is almost as cold as in London. But close at hand, in fact often under the tree-fern woods, are seams of coal which suggest that these great stretches of fern and moss have lingered on until to-day; though hardier types of fern and moss have taken the place of the old types.

Trees and flowers from the east coast, which got them from the warm islands beyond, now mingle with the fern forests of New Zealand; but in the coal forest there were no flowers. There were merely certain crude green seed-organs, that we might call flowerets, on some of the ferns; and in a later chapter we will trace the evolution of the flowers from these. There was a monotonous sombre green everywhere. No birds had yet appeared. No moths or butterflies, no bees or wasps, would be seen. There was no grass. Beetles, fat and stumpy spiders, and centipedes were everywhere. Great flying insects, unlike any that we know, measuring three feet across the wings, were the only creatures of the air. Wings began to be important, for the amphibious creatures that were evolved from the lung-fishes swarmed in the forests, and grew fat on the rich insect world.

We have innumerable fossil skeletons of these amphibians of the coal forests. Our frogs and toads were not yet born, but creatures of the newt and salamander type ran to a prodigious size. In the swamps was a giant salamander, about five feet long, which seems to have been the monarch of creation in those days. Almost in every case where a new family appears its members quickly run to a great bulk of body. Food is very abundant, and at first the competition for it is not so keen. After a time overpopulation begins to tell. The fat, sluggish types, which had had no work to do but eat, are very much

reduced. Food is less, and it must be hunted. Cannibalism is apt to begin, and the struggle of hunter and hunted brings out new forms, just as surely as a great war does.

So we find the amphibia of the coal forests branching out in many directions. Some small types become tree climbers, and no doubt they found a rich diet of insects in the trees. This reacted on the insects, and caused fresh developments among them. Some, as we saw, developed wings, and could at least soar from tree to tree. As these enjoyed good security, for there were then no birds or flying reptiles, it is natural to find them growing to a large size. They had fat, heavy bodies eighteen inches long. Other insects were fitted for survival by gradually developing such a shape and colour that they could not be seen at any distance. These were the "stick insects" which belong to the ancient order. They are very common in Australia to-day, precisely because Australia and New Zealand have the most primitive animal populations on the globe.

Other amphibia of the coal forest lost the use of their limbs, and developed long snake-like bodies. These give us an excellent clue to the development of the later serpent. The struggle for life among the amphibians themselves had become very severe, and some had taken to hiding and living among the exposed roots of the trees by the side of the swamps. If you have ever seen a picture of a mango forest at a

river's edge, you will understand this. The roots form a dense thicket, into which the giant salamander or large fish could not follow the little amphibian. But legs are useless in such a world. A strong wriggling body is needed; and the fossil skeletons we have show us that this branch of the amphibians slowly changed until they must have looked externally like water snakes.

These illustrations of the machinery of evolution during the long forest period will suffice. It seems to have lasted about a million and a half years; or the whole period we have just surveyed may have lasted ten million years. In spite of all the changes we have noticed, it was a period of slow evolution. Life is never quite stagnant, unless some race of living things is removed entirely from competition with others and has easy conditions. I mean that for a living family of low intelligence, which depends on almost mechanical stimulation from its surroundings, such conditions generally mean stagnation. They are rarely found, however, and we saw that there was a brisk struggle in the coal forests. Yet, when we think of the enormous period occupied by these developments, the pace of life was slow. Fat salamanders, fat insects, fat spiders, and so on, lived out the warm days sluggishly and contentedly. Now a fearful "revolution" is at hand, and new dynasties are to come to the throne.

CHAPTER V

IN THE GRIP OF AN ICE AGE

We have already begun to realize what a deep influence changes in the surroundings may have on the earth's inhabitants, although I have been able to give only a few illustrations. The struggle of land and water, which I have described, caused a great number of other new developments. Suppose, for instance, a vast marshy region, that had lain stagnant for hundreds of thousands of years, were tilted and drained, so as to form a great tract of dry country with a few swift-running rivers. The whole animal and plant population must change. The fish and shell-fish, the luscious plants and all that fed on them, down to the microscopic animalcules, the insects and amphibians, must give way to new types. If the changes are very gradual, the new types are largely their own descendants. There is time for evolution to adapt them to the new surroundings.

This was happening in very many parts of the earth during the period we have just considered; and we will glance at one further effect of such changes before we come to the great transformation which crowned them all. It is quite plain that the amphibious

animals which lived in one of the regions that were being gradually drained would become simply land animals. As long as they have both elements, land and water, they use both. But even in nature to-day we have frogs that live in trees or in almost waterless regions. We will suppose then that, as the waters are drained, these large primitive salamanders, as described in the last chapter, take more and more to the land. They will lose their gills. Their legs will grow stronger, and their feet firmer. In short, the salamander will become a reptile with a short, stumpy tail.

This new branch of the tree of life appeared before the end of the coal forest period. The reptile was the new monarch of the earth. He was very different from the snakes and lizards, crocodiles and turtles, of to-day. He had a thick, squat body, several feet long, a very short tail, and a head more like that of a frog. He was the patriarch of the reptile family, and the descendant of the salamander and the lung-fish. But he appeared for the same reason as they did: the land was gaining on the water.

At first the reptile also had a golden age. He can live in water, like a crocodile, or in a waterless desert, like some of the Australian lizards. What he chiefly wants is *warmth*. He is a cold-blooded animal. That is to say, his heart has only three chambers, so that the blood purified in the lungs is not kept completely separate from the unpurified blood, and it does not

keep a constant high temperature. In cold weather his blood grows colder. Also he lays his eggs—I mean Mrs. Reptile lays her eggs—in the open, and nature must supply the warmth to hatch them. In fine, a coat of scales is not particularly warm. He loves to be in the sun. But we saw that he appeared in an age of perpetual semi-tropical summer, and he prospered and multiplied exceedingly.

If there had been such things as scientists among those early reptiles, they would have made a strange and disturbing discovery. Let us suppose that they had records of the preceding ten million years. The climate would be recorded as "perpetual summer," as we saw. Surely it would last for ever! But these reptile scientists would presently make an unpleasant discovery. The earth was growing colder. If they could have got reports from all parts of the globe, it would have been the same story. Century by century the earth was growing steadily colder. In many places the land was rising, slowly, to unknown heights. Whole regions had to be deserted. The warm-loving vegetation of the time could not live in them. There was no food. The other regions became over-populated. There was the usual fierce struggle and active evolution. The hardier specimens had a better chance. They could live where most of the others could not. Some of them became gradually adapted to a cold climate.

To drop this little parable, and state the facts in a

word: the long perpetual summer of the early earth ended in a great Ice Age. That is to say, about four million square miles of the earth's surface were covered with a permanent sheet of snow and ice, as our Arctic and Alpine regions are to-day. We can detect traces of glaciers, or rivers of ice, millions of years after they have disappeared. Their weight is such that they grind pebbles deep into granite rocks, and the scratches remain almost for ever, in suitable places. There had been two earlier Ice Ages in the story of the earth; but, as we saw, there was then no life on land, and we have not considered them. This new ice sheet stretched from India to Australia and Africa. A great continent spread over that area at the time, and it must have been one vast Arctic region. I have seen the marks of glaciers of, say, nine or ten million years ago—the periods we have reached—in Australia.

Four million square miles are by no means the entire land surface of the earth, but the climate of the whole earth seems to have changed. No doubt there were smaller sheets of ice in other regions. Wherever there were mountains there would be at least a frozen winter-time. And there were now, for the first time in millions of years, many mountains. That is, in fact, probably the great cause of the Ice Age. I have carefully studied Ice Ages in my *Story of Evolution* and *End of the World*, and am convinced that, as many geologists think, *the* cause of Ice Ages is a great

elevation of the land. We saw that during the preceding period the earth was generally low-lying and steamy. A very thick atmosphere brooded over it, and, like the panes of glass of a hot-house, it kept the heat down at the earth's surface. This thickness of the atmosphere was partly due to the enormous masses of carbon (in the shape of carbonic acid gas, or carbon dioxide) in it. The great forests, which absorb carbon and give out oxygen, had altered this. But the dense moisture of the early atmosphere had the same effect. The great rise of land now altered the moisture. It swept up the cooler hill-sides and was turned into rain, or "precipitated." There was more running water, and less brooding moisture and stagnant water. This purification of the atmosphere, combined with the rise of mountain chains high up above the sea level, is enough to explain an Ice Age.

The change may have taken a hundred thousand years. Indeed, it was really the last stage of a change, the struggle of land and water, that we have traced for some time. There was no evident upheaval. What geologists mean when they call it a revolution —this period they call "the Permian Revolution"— is that the story of the evolution of life, taken as a whole, shows at this point a more rapid and fundamental change.

It is quite easy to see that the change of climate would certainly mean a revolution for animal and plant life. You may bring a negro chief from Africa

to Norway without much risk to-day, because you can give him Jaeger vests, a tweed suit, and a fur coat. But, if clothing were unknown, what would be the effect of transporting a party of Zulus to Northern Siberia? Well, as we saw, practically the whole of the earth's inhabitants had been living in an African climate, and the worst kind of moist African climate, for millions of years. No doubt there were some drier regions, as the land rose; but the fossil remains show that they were few. Nearly all the plants and animals of the time were suited only to a moist, hot climate, and were too sluggish to be re-adapted.

As a natural result, there was a prodigious carnage of the living inhabitants of the earth. This is the worst aspect of "natural selection." It is a fearfully effective method, but slow and costly and ruthless. We should say that it is a cruel and stupid method, only nature is not intelligent and responsible. People who call it a "law of nature," and so say that we must follow it to-day, are rather confused. It *was* a law of nature. That is all that science can say. However, we will return to this point later.

It has been calculated, from the fossil remains of the period before and after the Ice Age, that thirty-nine out of forty of all the species of animals and plants on the earth during the coal forest age were destroyed. They disappear from the calendar altogether. The luscious vegetation withered away. The dense forests died, and their remains were packed

underground, to become the coal seams of man's early industrial age. Nearly every type of the old vegetation was blotted out. We can trace some of the ferns and other trees gradually becoming hardier. We find pines and yews and firs, or their ancestors, now for the first time appearing on the earth. But it was a very thin diet they provided compared with what had gone before, and the fat salamanders and insects and other large-feeding, sluggish animals went the way of all flesh. Only a few types were preserved in warmer regions, to give us the amphibians, stick insects, beetles, spiders, etc., of the new age.

It was a great annihilation. Up to that time in the story of the earth motherhood consisted merely in shedding eggs on the surface of the earth or in its waters. To put it poetically, "nature" mothered the eggs. The warm ground or water gave heat enough to stimulate the wonderful mechanism in the eggs. In the colder age we are considering there would not be heat enough. Even if the mother got sufficient food to reach the egg-laying stage, the old habit of entrusting the eggs to nature was out of date; except, as I said, in favoured localities which kept the old conditions more or less, and must have been greatly overcrowded. A new habit, the practice of caring for one's eggs or young, was needed in a cold climate.

Then there was the direct effect of the cold. The

reptiles would have, at first, thin scaley coats of little use. The amphibians had the clammy skins of our frogs and newts. None of the animals had had occasion to develop warm coats. None of them had hearts so constructed as to keep the blood at an even temperature. However, the climate changed. I have walked on the brink of Niagara and by the lake side at Chicago in just the same clothing as I wear in the early summer in London, without any particular discomfort. The mammal has a four-chambered heart, and the blood is so well supplied with oxygen to burn its "fuel" that it keeps warm. None of the animals before the Permian Revolution had "warm blood." There had been no need of it, and needless things are not evolved. If some theories of evolution were true, they might be. On the lines of natural selection they are not.

But on the theory of natural selection they *are* evolved when they are needed, and this is the positive or constructive side of the matter. We have seen that the three great new requirements in the higher animals were care of the eggs or young, a four-chambered heart, and a warm coat. You probably know that these are the chief points in which the mammals and birds are superior to the reptiles. You will understand half of familiar nature better in future if you remember that these superior qualities were made necessary by a great Ice Age, nine or ten million years ago, and were evolved in the latter part of the

Ice Age. The bird and the mammal are products of an Ice Age.

We will try to picture what happened. The ice sheet spread over South Africa and the continent which then spread from Africa to Australia in the east and India in the north-east. Suppose we take the northern part of Africa, which was free from ice. Our African tropics would then be a "temperate zone." Further north there would still, no doubt, be large regions with warm conditions. But the overcrowding would be terrible. How many million "refugees" would there be from the icy continent? I do not, of course, mean refugees in the modern sense. The change had taken ages. The animals would migrate gradually. But in the height of the Ice Age the warm region would be packed.

On the fringes of such a region natural selection would be at work. If you take a thousand people at random in London, you find that some stand cold better than others. There are little variations of all kinds in every species. Now the power to stand cold would be an advantage in the conditions we are studying. Such individuals would be more active, and could get food enough in regions where others would starve. These would prosper in the "temperate zone," which would not be so densely inhabited. The more tender and sluggish among their offspring would perish. The hardier and more active would multiply. The standard of the population would rise. As they

increased, and the struggle for life increased, the hardier and more active would tend always to push into the *more* temperate parts. Any useful variation, such as the overlapping of the scales or an improvement of the blood circulation, would be fostered by natural selection. Just as lungs were the great thing needed at the earlier stage, so warmth—for the parent and eggs—is now the chief need. The machinery of natural selection worked, age after age, in developing heating-apparatus. The bird was one result; the mammal was another.

If we could accept the theory called "Mendelism," which I have mentioned in the first chapter, this would in one sense be easier to understand. According to this theory, evolution does not work by very slowly and gradually adding together little changes in successive generations, but by occasionally producing young that differ very materially from the mother. Such things are known, and used to be called "freaks." Many scientists believe that they are sometimes the beginning of new species. If we could imagine a mother with a three-chambered heart (a cold-blooded mother) laying an egg which hatched into a reptile with a four-chambered heart (a warm-blooded animal), or a long step towards it, evolution would be easier. But it is a large order, and the supposition does not seem to be justified by the facts. Most men of science still believe in gradual advances; though they lay far more stress than Darwin did on

the embryonic machinery which must be the cause of all advances. Surroundings only select the variations which are provided by the embryonic machinery.

These, however, are deeper matters than we can discuss here. The Ice Age may have lasted a quarter of a million years. It put the population of the earth through a sieve, as it were. The great majority of the plants and animals could not stand the test, and they were rejected. A few types struggled through, and they begin the story of higher animal life: the life of the birds and the mammals. But this figure of speech is very faulty in one sense. If the severe conditions of life had been spread all over the earth, it would be a good figure. But they were not, as we saw. There were still warm regions, where modified survivors of the old Golden Age huddled together. If the old warm conditions returned to the earth, they would spread over it once more. This is what happened. The ice-sheet gradually melted away, probably because the land gradually sank once more, and a new and curious chapter of the story of life opened.

CHAPTER VI

THE BRONTOSAUR AND ITS COUSINS

THE entire period we have covered so far is called by geologists the "Ancient Age" of the earth. It embraces more than two-thirds of the life of the earth. If you want to know the correct scientific names, there was first a very long period, probably as long as all the others put together, called the *Archæan Era*, which we may call the Very Ancient or Primordial Era. If you take, for convenience, the age of the earth as 100,000,000 years, this part lasted 50,000,000 years. There was life only in the later part of it, and no life on land. Then there was a long period of 35,000,000 years (on the same scale) which geologists call the Primary or Palæozoic (Ancient Life) Era. That is the period we have covered in the last three chapters. In this chapter we are going to survey the "Middle Ages" (the Secondary or Mesozoic Era) of the earth's story.

And some very quaint mediæval creatures there were in it, you will say! It was the age of the giant reptiles, whose hundred-foot-long skeletons you see in museums or works of science. It was the age of the Brontosaur, which was photographed and de-

scribed in all our newspapers a year ago. I am, as usual, not so much going to describe these things as to explain them.

We saw that reptiles had been developed from amphibians in the latter part of the coal forest age. They were a plain response to the change of conditions. Dry land was increasing. The salamander took to dry land, and became a reptile. But the dry land increased so much, and rose so high, that it threatened to strangle the new monarch of the earth very speedily. Fortunately for him, there were still warm regions, and there he awaited his turn. I imagined a group of reptile scientists keeping accounts. For a hundred thousand years or more they would report increasing cold, and dire would be the prophecies. Then for a hundred thousand years or more they would report *decreasing* cold, and hope would animate the chilly reptile breast. Never believe prophets who venture more than forty-eight hours ahead. (In the end of this work I will venture ten million years ahead—but that is different.)

The sun shone again upon the whole world. The new age was not as hot as the previous one, for the atmosphere was now purified of its great masses of carbon and moisture. But it was again perpetual summer all over the earth; no cold or frost or winter anywhere. It was more brilliant sunshine than before. Sombre trees like the yews and firs remained in temperate regions, but the new types of trees—very

largely the palm-like trees called "cycads"—spread luxuriantly, as the cold retreated from level to level. Large yellow flowers, the first touch of colour (except dark green) the earth had yet known, responded to the bright sun. These I will reserve for a later chapter, and the reader must go to larger books for the names and pictures of the new plants. It is enough here to say that in the new Golden Age the vegetation wove once more a thick mantle over the earth, and food became again enormously abundant.

The height of the land explained the cold. The lowness of it now explains the warmth. It was as if, in our great struggle of land and water, the land, which seemed to triumph in the Permian Revolution, was again worsted for a time. This may remind you of the French Revolution, and it is a very good parallel to remember. The sluggish old types of monarchs were dethroned at the Permian Revolution, with great bloodshed, and progressive new rulers of the earth were introduced (the bird and the mammal). But there was a great reaction, and the sluggish old monarchs came back. The reptiles are now to lord the earth for a few million years. The bird and mammal will slink into such obscurity that we need not notice them. To complete the parallel, we shall see that this reaction will be shattered by a new revolution (which we may compare to the revolutionary movement of 1830–2), then there will be a moderate reaction, and finally another great revolution

(which we may compare to the period 1848–70). It is said that there will be another Ice Age some day!

To return to our Middle Ages and Brontosaurs. The earth was again generally low-lying, but sunny and with a clearer air. Europe was mostly under water. Only the summits of its higher hills peeped above water, apart from a few regions which are now elevated table-lands. Europe was, in fact, mainly an archipelago, like the Pacific Islands. A warm blue ocean, with prodigious sharks and swimming reptiles, covered the greater part. Coral reefs of great beauty fringed the islands; we find their remains now high up on our mountains. There was more land where the North Atlantic now is than in Eurpoe. A swampy continent stretched from Scotland to America, and the great animals wandered (as species) from continent to continent.

These conditions explain the Brontosaur and its cousins. Probably most of the larger reptiles were swamp animals, floating their great bulk on the water like the hippopotamus. If you notice carefully the very small allowance of leg to the monstrous skeleton of the Diplodocus in the South Kensington Museum, and the breadth of foot, you will realize this. One can hardly imagine it walking, much less running! Probably most of these larger "Deinosaurs," as this group of the reptiles is called, were aquatic animals. Food was very abundant, and they were vegetarians, taking in, lazily, tons per day of the

luscious vegetation that abounded. The Brontosaur was quite a modest member of the family. He weighed only about twenty tons when he was fully grown! But as his length was only sixty feet, the Diplodocus (eighty feet) must have been much heavier; and we now know, from bones we have found in America, that some of these Deinosaurs were about twice as long as the Diplodocus, or a hundred and sixty feet long.

Another branch of the family were leaping reptiles. Some stood only about two feet high, when they were erect, and others thirty or forty feet. There were some with hollow bones, like birds, so that we must not allow the lazy monsters of the swamp to mislead us. The new "Golden Age" was not long an age of tranquillity and mere feeding. The inevitable struggle for life began. At all periods in the history of the earth part of a family has been apt to turn carnivorous and prey upon its fellows, and the skeletons and teeth of the great reptiles show that this terrible struggle set in in the Mesozoic Age. Teeth grow larger and more numerous and more carnivorous, until at last we get appalling flesh-eating monsters with two or three hundred formidable teeth in their jaws.

Armour, as is usual, keeps pace with the development of teeth. Ponderous and sluggish vegetarians, forty feet long, developed rows of great plates of bone standing upward from their backbones. Others had massive coats of horn over their heads and necks,

running to sharp points in front. Towards the close of the period we find perfectly weird developments of jaws, teeth, and armour. Professor Huxley was quite right in saying that "Nature, red in tooth and claw," had been the great agency in evolution. It is only at a much later stage that we shall find the gentler influence of social life becoming a factor of any consequence in development.

The struggle of vegetarian and carnivore explains much more than the development of arms and armour. If you go into the fossil reptile gallery of a great geological museum, you are amazed at the variety of types which grew out of the primitive simple family. In the centre of the gallery you will find the monstrous thigh bones, and perhaps whole skeletons, of the vast Deinosaurs, which lazed in the swamps. Near them are mounted skeletons, standing up twenty or thirty feet, of reptiles whose long and powerful back legs make them look like kangaroos. They were the leapers. On the walls are the fossil remains of others which lived entirely in the sea; some with fish-like bodies and well-developed paddles, some with long necks that could reach to the bottom in search of food, some with eyes fifteen inches in diameter or jaws like crocodiles. In other cases are the skeletons of flying reptiles, from small creatures about the size of a wild goose to villainous-looking "dragons" with a stretch of twenty feet across the

expanded wings and jaws that would bite a square foot of flesh out of an elephant.

This variety is an expression of the struggle for life. Every little advantage for escape was favoured and strengthened during hundreds of thousands of years of conflict, and the branches of the family spread in all directions. Some went down into the sea, where great sharks were their only competitors. Some developed powerful back legs, and could outpace even a running carnivore. They were often far larger than the giant kangaroo, and must have been able to do a remarkable "long jump." Some climbed trees, and it is probably from these relatively small and active creatures that the flying reptiles were evolved. Some think that flying began with running, but it seems more likely that its origin was in leaping down from low branches of trees when a pursuer mounted the tree. Webby fore-feet would be an advantage. The animal could, in our aeronautical language, glide or plane down to the ground; and a long course of this evolution of "webbiness" would at last give a powerful membrane from the first toe (which grew to a length of several feet) to the side of the body—the plane or wing of the flying reptile.

As far as general principles are concerned, therefore, we very fairly understand the wonderful family of reptiles—some writers strangely persist in calling them "lizards"—which filled the land, the waters, and the air of the earth's Middle Ages. There are a

great many controversies about the origin and relations of different types, but these things cannot be discussed here. It is only necessary to add that the remainder of the animal world continued to make the same progress, though while these monstrous and curious brutes occupy the Mesozoic stage the others have little interest.

The bird and the mammal were there, in very primitive forms, all the time; but the reptiles, if they had had the power to reflect, would have considered them very insignificant. They were so small and furry, or feathery, that they were not even good food. A reptile philosopher would have regarded them as freaks of the family. He might have said that they were what we now call "anachronisms"; that is to say, things that had had a sensible meaning at one time or other, but ought to have died out in the age to which they really belonged—the Ice Age. What use were fur and feathers, four-chambered hearts, and making a fuss over one's eggs or young, in a gloriously warm age like the Mesozoic? Their one advantage was brain, for better blood meant a better-nourished brain. But their advantage in this respect was not overpowering—they had less brain than a rabbit or a goose—and, in any case, brain was not much regarded in that age of brawn. A twenty-ton reptile like the Brontosaur had a brain no larger than a man's fist.

So we leave the mammals and birds for later chapters. The amphibians naturally throve like the

reptiles in the return of the conditions of the golden age. There was again plenty of water, warmth, and food. Early in the Mesozoic Age they spread over the earth, and grew to enormous proportions, owing to the abundance of food and the relative scarcity of enemies. "Amphibian" to-day means to us a frog or toad or newt, a small and despised thing. In the Mesozoic Age you might have met one peeping out of the water-vegetation with a head three feet long and two feet wide. But the reptiles occupied the same world as they did, and had greater advantages. The amphibians grew less numerous and smaller, approaching more and more to the types that we know to-day.

The insect world was developing, and we will consider this later. In the waters the population was making the same steady and sanguinary progress. The fishes made great advances, the types with bony skeletons now appearing for the first time. Most people are so familiar with fish bones that they can hardly think of a fish without them. Many know, however, that fishes of the skate family have not real bones, but a frame of cartilage. As we should naturally expect, the earlier fishes had skeletons of cartilage, which always precedes bone.

But the waters were now a worse scene of terror than ever. New types of shark, with the formidable cutting teeth of our shark, though enormously larger, had been evolved. In addition to these there were

now the swimming reptiles, some of which had, as I said, swift fish-like paddles, eyes fifteen inches in diameter, and crocodile-like jaws adorned with about two hundred teeth. We do not wonder that the geological chronicle shows a rapid improvement of the fishes—especially of their power of getting away—but we will not go into the details.

Every section of living nature had new terrors and new enemies. There was, as yet, no social life, except among such animals as corals and sponges and polyps, which have no intelligence (and most probably no consciousness whatever) to profit by it. Carnage, and changes of land and water, were the great stimulants. Besides the sharks and Ichthyosaurs, for instance, there now appeared in the ocean the king of the shell-fish family, the Ammonite. He lived in a great curved shell, like a coiled snail's shell, which was sometimes three or four feet in diameter. At the opening of this he watched for his prey, with great eyes and a huge expectant mouth. He greatly helped the world of small invertebrate animals of the sea to move on to a higher level.

But we will keep to the broad lines and general principles of the subject. This Mesozoic Era was, as I said, a period of reaction between two revolutions. With the second revolution we open, not exactly the modern period, but the period of the ancestors of our modern types, and we move in a world that is less strange. The revolution was, of course, another

severe chill of the face of the earth. There are traces of glaciers here and there, but they do not amount to very much, and we do not speak of an Ice Age. But there is a real revolution in the life of the planet. The Mesozoic Era ends with the time when the great chalk-beds, composed of the "shells" of myriads of dead animalcules, are laid down on the floor of the ocean. During this Cretaceous (Chalk) Period there is a slow transformation of the world of life. The great reptiles disappear; and most of the smaller types, the survivors of that powerful dynasty, retire into the tropics. This obviously means a chill. The north is too cold for them, food is less abundant, and leaving eggs to the care of nature is no longer possible. Cold killed the reptilian monsters.

At the same time, naturally, we find an expansion of the birds and mammals. Not only are their fierce enemies removed, but the conditions for which they are particualrly fitted—cold climate and brisk movement—return to the earth. It is a good example of what we mean by "survival of the fittest." In the Mesozoic Age the reptiles were fitter than the birds and mammals. The latter were far superior in brain and organization, yet they were the less fit for those particular conditions. When the cold returned, the conditions of the struggle were reversed. The huge, heavily armed, and armoured reptiles were the "unfit." In spite of all their strength, they gave way to tiny, rabbit-like creatures and birds.

There is a corresponding change in the earth's vegetation. Up to this point it has been an evergreen earth. There was no winter, no need to shed the leaves once a year. Now, in the Chalk Period, we find in America the traces of trees which shed their leaves periodically. Winter has become an institution of the northern hemisphere. Before the end of the period we find the older types of trees giving way to the willow and birch, the oak and mulberry, the laurel and myrtle, the maple and elm, the walnut, and dozens of other familiar trees. New flowers in great variety appear. We will consider this opening of our modern world in the next few chapters.

CHAPTER VII

THE EVOLUTION OF THE FLOWERS

THE reader may now begin to understand the large variety of living nature. But there are, as I know from questions at the close of lectures on Evolution, always a few who say that this variety is puzzling from another point of view. Why do the older types of animals and plants remain at all? One can understand that in the beginning all animals and plants were "microbes" (single cells). One can follow the story when the man of science says that life later rose to the level of the ferns and mosses, the jelly-fishes and corals; later again to that of reptiles and cycads; still later to that of roses and eagles and men. But why did not the whole world move on? Why did not ferns and salamanders and lung-fishes, etc., die out when they gave birth to higher forms? Or why did they not all evolve?

One has only to take a simple and important example, and the answer is plain. The fishes gave birth to the land animals, which are much higher. But it would be obviously absurd to expect the fishes then to die out, or all to leave the ocean. The waters remained their natural and sufficient home, while the

land provided a new home for the "surplus population." One might as well say that Englishmen ought to have died out when they sent colonists to America and Australia! This is the principle to bear in mind: *The old or original environment remains good for the old type.* The new type may even live in the same region, but it has new habits or a new diet. Nature really provides half-a-million environments. So you get half-a-million species in them. There is life wherever there is an environment.

This is quite plain in the case of the plants, which we are now going to consider. Omitting the microscopic and other early types, there was a time when none existed above the specimens of what you may broadly call the "sea-weed." Some of these invaded the land, and were gradually transformed, in the new conditions, into ferns and mosses. But this did not make the least difference to the sea-weeds themselves. The sea was as good a world as ever for them. In course of time the ferns and mosses begot higher types. But the particular sphere of ferns and mosses remained. Your humble moss is still monarch of its own environment; say, the moist, shaded hillside. It is particularly fitted for that world, and thrives there better than higher plants would. The pine and yew were born of a remote Ice Age. But there are plenty of cold and hardy regions for them, and they remain.

Thus, while the plant world has been marching on through the ages, it has like the animal world, left

regiments behind at each station, as it were, and these represent the stages of advance. A microscopist will show you in a drop of pond-water the tiny one-celled *algæ* which remain at the lowest level of plant-life; and he may then show you chains or clusters of *algæ*, representing the next great step, the formation of a many-celled body. The botanist would then show you how, in the course of time, some of the cells "specialize." Some make the stem, some the leaves, some the roots, some the spores or seed.

But I have not space here to consider the very rich evolution of the plant world. If I gave only a general outline of it, the result would be a bewildering variety of technical names. Some teachers think it real instruction to insist on a certain number of technical names. It is not, unless a pupil is definitely learning a particular branch of science. These names cause brain-fog, unless they are thoroughly learned and analysed. That is good in its place, but this is not the place for it. We will rather make a general survey of the evolution of flowers.

The various parts of a flower are leaves which have been modified for their particular purposes in the course of evolution. In a growing flower or a very primitive flowering plant a botanist can clearly demonstrate this. Here we will take it for granted. The lower types of plants have spores, not seed, and no flowers; but it was found some years ago, on examining certain ferns which were beautifully pre-

served in the coal, that they had seed and seed organs instead of the usual spores. They were branching, as all living families do. One branch of the coal forest plants was, under the stress of the Ice Age, going to produce the pine and fir, the cones of which are neither flowers nor spores. Another branch, the seed-bearing ferns, was going to produce the flowering plants.[1]

The crude green "flowerets" of these seed-bearing ferns are almost lost in the confusion of the Permian Revolution, and it would be a sin against the purpose of this little book to follow botanists in their learned attempts to trace the evolution. It is enough that the Ice Age closed the long reign of the lowly spore-bearing plants, and opend the era of flowering plants and conifers. We saw the Mesozoic plains were covered with Cycads, palm-like plants with crude types of flowers, or "fructifications." The colours we can only estimate. Probably at first they were predominantly green, and, as time went on, yellow gained upon the green. It is not thought that these were the parents of our flowering plants. Probably some hardy seed-bearing type of fern remained, during the age of the great reptiles, on higher and cooler levels, waiting, like the bird and mammal, for the return of the cold.

[1] See, for a short and authoritative account, D. H. Scott's *Evolution of Plants* (in the "Home University Library"). It is not simple reading.

The cold of the Chalk Period gave them their opportunity. Then, as we saw, the flowering trees and plants spread from eastern America, which seems to have been higher than the west, and over the whole northern hemisphere. There was still land across the northern Atlantic, and in the very slow way of forests they gradually reached and overran Europe. Not only the trees I named, but the oleander and magnolia, the palm and the grass, the lily and orchis and iris, now came upon the stage. From green the earth had turned partly yellow. From yellow it now turns white.

As flowers are not fossilized, one is often asked how we know that there were these successive waves of colour. It is, of course, an inference; but it has good grounds. If you arrange a large number of flowers according to their degrees or stages of organization—according to the complexity or simplicity of their seed organs, petals, and sepals—you will find a pronounced colour scheme. The simplest are predominantly yellow (green at first). Those of the next stage of organization are mainly white, with some red. The colour red predominates in the next group; and at the top you get blue and variegated flowers. As this corresponds with their evolution in time, the simplest naturally coming first, we gather the successive appearances of the colours in nature.

It may also be asked how we can read the change of climate from the appearance and triumphant

spread of our higher flowering trees. This is simple when one learns *why* a tree sheds its leaves in the winter. The leaves are more or less the lungs of the tree. Through them it gives off moisture. In the winter, however, it receives little or no moisture from its roots, according to the state of the ground, and the leaves are sacrificed in order to preserve the moisture in the tree. Here, again, one sees the last term of a long evolution. The various steps of it have been lost. It may have taken place on "the Lost Atlantis."[1] In any case, when we do find these "deciduous" (leaf-shedding) trees appearing in the Chalk Period, we know the meaning. The earth is growing colder; winter has begun.

But the great chill which killed the reptiles and opened the reign of the birds, mammals, and flowering plants melted away again like its predecessors. The temperature of even the northern hemisphere rose so high that magnolias, figs, and bamboos flourished in Greenland, where men can now barely wrest their remains from the frozen soil. Palms and aloes flourished in France. Warm-loving animals wandered as far north as Scotland. It was not so warm as it had been in the earlier periods, and from this point onward the earth becomes increasingly cooler; but

[1] I use the name fancifully for the continent which so long *did* exist across the North Atlantic. But it disappeared before the coming of man, or at least long before civilization, and there is no foundation for the Greek legend of a Lost Atlantis.

the genial climate of the whole earth lasted long enough to permit a great expansion of the flowering plants. The landscape slowly took on the features which make it familiar to us to-day. But the world was to pass through a mightier chill than ever before its modern appearance would be finally reached.

At the time of the spread of the flowering plants there was also a rapid evolution of the insect world. Now the bees and wasps, ants and flies and butterflies, came upon the scene. We saw that the coal forests had had only primitive large flying insects, beetles, and other lowly types. We saw that wings are developed frequently in the course of evolution. Wherever there is a great struggle for life, some of the hunted will try to escape into the broad free atmosphere which floats above the teeming ground. Even fishes, in the tropics, have developed a certain power of flying, or rather "planing," away from their enemies; and to see a flock of these "flying fishes" rise out of the water—if they are near the ship, you can sometimes see the dark shade of a shark approaching—gives one an idea of the beginning of the evolution of flight. You might almost say that the same thing is happening under our eyes in England to-day. Man is struggling to rise out of his congested roads and travel in the free air. So insects, and reptiles and birds, bats and "flying foxes," have at different times escaped from the struggle on the ground by developing wings.

The active flying insects naturally developed very richly when the earth became covered with flowers. One has only to watch the swarms of them hovering about the flowers in the summer to realize how the two worlds would grow simultaneously. Probably everybody now knows that the insect is useful to the flower in return for the food it gets. It is an advantage when the pollen of one plant is taken to fertilize the seed of another plant, instead of fertilizing its own seed. The wind may perform this service, and does in the case of some plants; but it is a clumsy and wasteful process. It is far more effective when the little bee, poking into the depths of the flower for the honey which is prepared for it there, gets the pollen on its body, by rubbing against the stamens, and unconsciously carries it to the next flower. This is "cross-fertilization," which is better than self-fertilization.

It is generally believed that the colours of the flowers are a sort of advertisement to the insects. The yellow leaves of the buttercup—they are, like all other parts of the flower, transformed leaves—practically mean to the distant insect, "Free food here." There has been some dispute in recent science as to whether the insects really are attracted by colours, but the experiments that have been made seem to show that this is the case. Naturally, the insects and the flowers must have developed together. It takes ages to evolve any arrangement of this kind,

and it would be very unscientific to imagine first the flower world slowly evolving its attractions, and then imagine the insects discovering the secret in some wonderful way. All through the period of the great reptiles, flowers and insects and their mutual service must have been developing simultaneously.

But the mighty expansion of the flowers after the severe chill of the Chalk Period would in turn lead to a tremendous growth and rapid development of the insects. We have so often seen the principle on which the machinery of evolution works that it is hardly necessary to repeat it here. It is absurd to imagine a "vital force" pushing evolution in this or that direction. That is merely playing with words. It is equal to saying that "something or other did it," and then imagining that you have explained the matter.

You understand it much better when you remember that the flowers which were cross-fertilized had the best chance of growing the next generation, and that those flowers had the best chance of cross-fertilization which provided sweet food for insects and some means of letting the insect know that the food was there. Then imagine the broad sunny continents of the Tertiary Era, which we have reached, teeming with flowers. It was still so warm, remember, that figs and bamboos grew in Greenland. There would be an intense struggle among the seed, and the

cross-fertilized would have the advantage. Natural selection would foster and increase every trick and apparatus that led most surely to cross-fertilization.

To work out this principle in the world of flowers, and explain the wonderful variety of flower structures, would require a whole large volume, or series of volumes. One must consult botanical works. Here we can only consider broad features of the evolution of nature. One of these is that the great outpouring of the flowers came naturally after the severe chill had removed the large imperfectly-flowering plants of "the Middle Ages," along with the monstrous reptiles and other mediæval types; and that with the expansion of the flowers came the spread of the bees and wasps and butterflies.

You may think that flies and butterflies cannot be fossilized, and so the man of science must be guessing what happened millions of years ago. He often does guess, though he is always careful to tell you that it is only a guess, until he has found positive evidence to prove that his guess was right. But here we have direct evidence. Did you ever see a piece of amber with a fly in it? There is a shop near the British Museum in London where you can buy one at any time. That fly may be two or three million years old. Amber is more or less fossilized resin; and ages ago the fly stuck on the resin, as it oozed from the tree, and was covered over with fresh outpours of resin. Then the tree died and the resin broke off;

and it has beautifully preserved insects of three million years ago for us to examine.

In other cases myriads of insects have fallen into the mud at the bottom of lakes, and been preserved. In some cases myriads have been buried in the fine ash of a volcano. We have countless specimens, and they help us to restore the scene after the reptiles had gone. It now had large numbers of our familiar trees and flowering plants. It began to have grass on its plains. It had bees and wasps and butterflies going from flower to flower. Next we have to bring the birds on the scene, and then we will introduce our familiar mammals and man.

CHAPTER VIII

THE COMING OF THE BIRDS

We seem to have neglected the birds for a long time. They had really appeared several million years before the age we are now considering, and it may be supposed that such highly organized creatures, living in the free air, would have prospered and spread considerably during those millions of years. As a matter of fact, we find very few remains of birds in the rocks which represent that very long period. If the living things of that age are buried in anything like the proportion in which they lived, there must have been extremely few birds.

A word of warning about these "fossil remains" may usefully be given here. Some people ask us why, if the animals of the past are buried in our rocks, we cannot find whole series of remains showing the gradual transformation of, say, a reptile into a bird or a mammal. Now, that is one of the questions which ought not to be asked by any person who makes a good use of his eyes. Just look round a region that is teeming with animal life—say, a wood. How many remains of those myriads of insects and birds and other animals will there be left in a million

years? Probably none whatever. The bodies must be deposited in certain rare conditions to be preserved and "fossilized." They must be put, as a rule, in the mud at the bottom of stagnant water. As the vast majority die on land, they are not preserved at all. Only a tiny fraction of the things that have lived on the earth are thus preserved.

So the story of evolution as it is written in the rocks is very imperfect. Here and there it is almost complete for a page or two. For instance, shell-fish are easily preserved in lakes and there are cases where we can trace gradual evolution for quite a long distance. Sea-urchins are easily preserved in chalk-ooze, and we can in many cases follow their gradual evolution a long way in our chalk cliffs. But these are exceptions. In other cases the bones are still numerous enough to enable us to follow the gradual evolution very fairly. We shall see this in the case of the horse and the elephant. In most cases only a specimen here and there in ages is preserved, by some chance or other, and we are lucky to get these.

That is the situation as regards the evolution of the bird. Only one specimen (or two specimens of the same bird) has been preserved in the rocks from the hundreds of thousands of years during which a branch of the reptiles was being transformed into birds. It was found in certain rocks in Bavaria. Millions of years ago the bird flew in the atmosphere of Europe, which was then mostly under water, as

we saw, and its body was buried in a fine mud at the bottom of a lake. Probably many were so buried, but most of the rocks are still deep underground and unexplored, while others have since been ground up and used over agin. We were lucky to find this petrified *Archæopteryx* (Ancient Bird), as it is called.

It was about the size of a crow, and its various parts have been so finely turned into stone that, as far as external appearance goes, we might as well have the actual body. It has the unmistakable feathers and wings of a bird. But it is like no bird in the world to-day. It is half a reptile. There is a long tail, like that of a lizard; a clear continuation of the backbone far beyond the back legs, with large feathers sticking out on each side of the tail. It has two rows of teeth in its jaws; and no bird in nature to-day has teeth. It has also perfectly formed feet and claws on its front limbs, its wings; and there are very few birds in nature now which have such toes, though the majority have, underneath the skin, stunted little bones which represent them.

In the early days of evolution people used to talk much about "missing links." In this case a very important missing link was recovered. It is the link between the reptile and the bird. If it were not for the feathers, we should call it a flying reptile. It perfectly illustrates the gradual conversion of a reptile into a bird, as we sketched it in an earlier chapter.

We saw that this evolution was an outcome of the

Ice Age. In the colder regions no ordinary reptile could live. The animal itself was cold-blooded and thinly clad, and it provided no warmth for its eggs or food for its young. In the stress of the struggle that must have followed in the overcrowded warm regions, pioneers with favourable variations were able to survive in more temperate localities. We must not suppose an animal suddenly changing from a three-chambered to a four-chambered heart. Even here gradual development is not so difficult as may be imagined. Some of our reptiles to-day have hearts that are not *strictly* either three-chambered or four-chambered. There is a sort of effort to get a fourth chamber.

The feathers are less difficult to understand. They are transformed scales. Look again at the next hen you see, and you will notice that the scales which cover its legs really bring it nearer to the reptile than you had supposed. Examine a feather, and you will see that it is composed of the same material. Feathers are scales lengthened and "feathered," if one may use the expression. The feather as we know it is the outcome of millions of years of an evolution which aimed at combining warmth with lightness. Even the little *Archæopteryx*, whose remains we have found, does not belong to the Ice Age, but a very long time afterwards. Its feathers are well formed. There must have been myriads of earlier stages, with large heavy scales becoming gradually more "feathery."

As to the beginning of the care of the eggs, we have, naturally, no positive knowledge whatever. Nesting is very varied in nature to-day, and is in some cases extremely simple. I would venture to conjecture that for millions of years—possibly until the last Ice Age—birds did not nest at all. But they must have begun early to brood over the eggs. If the mother needed feathers to keep her warm, the eggs needed warmth to hatch. Here again there is not a quite sudden leap from the reptile world. Some of our living reptiles bury their eggs in a sort of "nest."

These are merely general and superficial considerations. I am only sketching the broad lines of development. It is not possible or desirable here to go more deeply into the matter. Special authorities on birds must be consulted. I merely wish to make the bird world broadly intelligible. Even children to-day ought to know more than that there are birds because there is air, and fishes because there is water, and beasts because there is land. The doctrine of evolution, which throws such a wonderful light on nature, is shockingly neglected in our schools. "Nature study" is a poor thing without evolution.

There are birds because once upon a time the earth was for two or three hundred thousand years in the grip of an Ice Age, and in some regions all the higher animals (reptiles) would have perished if they had not developed the "heating-apparatus" of the bird.

The mammals came for the same reason, at the same time, from the same reptile world. But the Ice Age melted away, as we saw, and the birds and mammals had no advantage in their higher organization. Fur coats, that you could not get rid of, were not a good equipment in an age of warm perpetual summer. Brooding over eggs was unnecessary, and unnecessary labour is not encouraged in nature. So we are not surprised that bird-remains are very rare. In rocks which represent several million years of the Mesozoic Era we have found only these two specimens of one bird.

Towards the end of the Age of Reptiles, in the Chalk Period, we find a few others. They belong to fully-formed birds of quite different types, and they tell us that the bird world was now expanding. The earth was cooling. Possibly the monstrous flying reptiles, which would gulp down one of the early birds like a dragon-fly, were being driven out of large temperate regions, and making way for the birds. As soon as they became lords of the air, they would, like all new families, spread richly, and in different directions.

In one feature the birds of the Chalk Period still bear the trace of their earthly ancestry. They have teeth, either separate real teeth or toothed jaws. It was a matter of evolution and progress for these teeth to disappear. They meant weight *at one end* of the flying machine; and in the course of development

the bird became able to grind its food in its crop, and thus dispense with the teeth. One of these birds of the Chalk Period seems to have lost the power of flight, so that we are not surprised that it has teeth. It was a swimming bird, like the diver, about four feet high. The other is a small flying bird; though it has distinct teeth, in sockets, in its jaws.

These belong, as I said, to the latter part of the Age of Reptiles, when the climate was growing colder. At the close of that period the flying reptiles perished so completely that not a specimen is left in nature to-day. The air was left to the birds and insects. The warmth and abundance of food returned. The outpouring of flowers fed the insects, and the vast swarms of insects would feed the birds. The rocks now show a great expansion and multiplication of species, which we cannot follow here in any detail. It is enough that our familiar birds begin to appear. Ages before man came along there were owls and parrots and many other types. There were still no Arctic regions or Alps, remember; and warm-loving birds could roam all over the earth.

In order to throw a little further light on the bird-world I will anticipate a little. For two or three million years after the birds had taken undisputed possession of the air the climate of nearly the whole earth remained more than temperate. Monkeys lived in what we now call England. Elephants browsed on the low hills which are now the Dogger Bank under

the waters of the North Sea. Sea-serpents wandered up the mouth of the Thames, and rhinoceroses and hippopotami splashed in the rivers of Yorkshire.

But the earth was growing colder. I am not satisfied that any good explanation has yet been given of this progressive cooling of our globe, and I will not speculate on it. Ice Ages we fairly understand, as an effect of the rise of the land; but general cooling and the formation of permanent ice-caps at the Poles have not yet been explained. We will simply state the fact. The northern hemisphere became more and more temperate. The warm-loving plants and animals were slowly driven south. The land was rising in very many parts of the earth. The great masses of the Rocky Mountains and Andes, the Alps and Atlas and Himalaya, were during all this time slowly rising towards the snow-line. A new Ice Age was approaching. This, of course, explains much of the cooling of the earth, but there is a steady lowering of temperature which it does not explain. After an Ice Age the earth never returns quite to the degree of warmth which it had had before.

However, the Ice Age at last set in. Seven million square miles of northern Europe and America were covered with permanent ice and snow. Glaciers, immensely larger than those which now flow slowly down the flanks of the higher Alps, flowed from the hills of Scotland, Cumberland, and Wales. I will say

more about this later. It had prodigious influence on animal and plant life, as will be imagined after our description of the Permian Revolution. This was a far greater Ice Age.

Bamboos and magnolias had long ago retired south. Now, as the ice-sheet spread south as far as the valley of the Thames and the Danube, the whole population fled before it. The change was, as ususal, extremely slow, and the reader will not misunderstand when I speak of even the plant-world retiring before it. Only the south of Europe and Africa—they were then connected by land—now bore the wealth of flowers on which the insects lived, and the birds followed their food. Hardy types, the birds of the Arctic and Antarctic, were evolved, but the vast majority retreated with the warmth and the insects.

Probably many features of our insects and birds were developed during this long and severe trial. The instinct of nesting would be fostered in the birds, and probably it was then that the ants and bees developed their elaborate ways of preparing against a "lean" season. The migration of birds may also receive much light from this geological event. It is known that migrating birds do not simply fly "somewhere south," where there are flowers and insects. Each family has its winter resort, and they follow particular and often curious routes to it. It is supposed that they go back to their homes in the Ice Age, and they follow routes which were at one time "all land"

routes. There is really no such thing as "instinct." The habits of the birds have been evolved under pressure or guidance from without. So there is nothing to "tell" them that land and water have changed very much since the days of the Ice Age, and year by year they follow the old routes, many of which ought to have been altered long ago.

CHAPTER IX

THE TRIUMPH OF THE MAMMALS

THE birds are our "sisters" in a way that poets do not know. We, the mammals, and they were born together of the Permian Revolution. We are the common offspring of an Ice Age. That is the original reason why we are "warm-blooded." And warm blood also means better blood, better nourished brains, so that it was a great advance in organization. Surely these things make nature more intelligible than it was even to the more learned of our forefathers? But we will now consider more closely the origin and spread of the vast mammal family to which we belong.

Mamma is the Latin word for breast. Our very young children are not aware that they are speaking a famous dead language when they address their mothers by that word, but it is a fact that to the Roman baby its mother was above all things a *mamma*—a breast. The mammals are therefore the animals with breasts; or, to take their leading differences from the other Vertebrates, with breasts, a womb, a four-chambered heart, and a hairy coat. You see at once that all these superiorities mean, first,

an adaptation to a colder climate. They mean warm blood and care of the young.

We saw how the first mammals arose. One progressive branch of the reptiles, which passed safely through the sieve of natural selection during the Permian Ice Age, was capable of being adapted to the colder climate. It is little use to give you its name here, though scientific men are now fairly decided which branch of the ancient reptiles it was that took this fortunate turn. The heart became four-chambered, and the blood warm. But again there was no sudden leap; in fact, there is not in nature to-day a perfectly clean distinction between the lowest mammals and the higher reptiles. "Warm blood" means, as I said before, that the blood system has the power to keep the blood at a fairly even temperature while the temperature outside may vary considerably. In plain English, it means having warm blood in cold weather. The blood of the reptile sinks with the temperature of its surroundings. That is the chief reason of the winter sleep of the tortoise or the snake. But the lower mammals have not entirely "warm blood." Their blood varies as much as 30° F. in temperature. They live in Australia and New Guinea, and are therefore not inconvenienced by a severe winter. This imperfectness of their machinery is quite a good illustration of evolution.

The fur coat, or coat of hair, is fully developed in every mammal that we know, and we can only guess

how it was evolved. The reptiles' scales did not evolve into hair, as those of the ancestor of the bird were transfomred into feathers. Probably the hair grew up out of the skin underneath the scales, and eventually made the scales superfluous. When one of the lower (not the lowest) mammals is developing in the womb, and the hair begins to appear, it grows in tufts or patches, as if each had originally grown under a scale.

You notice that in this case I look for guidance to one of the *lower*, but not *lowest*, mammals, and this may surprise you. The fact is that the lowest mammal in nature to-day—you will be introduced to it in a moment—has *no* womb in which it bears its young. It lays eggs, as snakes or turtles do. And this throws a very interesting light on the evolution of the third and greatest feature of our mammal family, the nourishing of the young.

As we saw, the mothers which would carry on their species through the stress of the Ice Age must, if they lived in the temperate regions, care for their young. The bird continued to lay eggs, but, unlike the reptile, provided warmth for them with its own body. An alternative way would be to hatch the eggs *inside* the mother's body, and this line the mammals have followed. Every animal that is born comes of an egg; though, to use a colloquialism, "there are eggs and eggs." At first, however, the ancestor of the mammals continued to lay eggs, like its reptile foremothers—I

nearly said forefathers. But when the eggs were laid, the mother had a nest ready for them, perhaps underground, to keep them warm.

This is the same as the birds, you may exclaim! No; because when the little animals came from the eggs the mother fed them from her own breast. The flesh and skin of her breast were perforated, or had a number of large pores in them. When the young licked this part of her breast, the fat-cells from her blood oozed through, and the young were nourished. It was the primitive milk. I need not point out the great importance of this change, and the corresponding change made by the bird. All animals had hitherto been strict individualists. There were, it is true, social groups of corals and sponges and a few others; but these have no consciousness at all of their "socialism." All parents among the higher animals were purely selfish, and took no care of their eggs or young. There was no need. Mother earth provided everything. From this time onward there is at least a link of mother and young, a beginning of social emotion. You see what an Ice Age can do!

But how *do* we know all this if, as I said, the Permian Ice Age was at least nine or ten million years ago? Even if we had found a fossil, like that of the "Early Bird," we could not possibly infer from it half of what I have described. It is true that we could not from the bones alone. Some writers credit men of science with almost magical powers. There is a

story still in circulation that a distinguished man of science once said that, if you gave him a single bone of some dead animal, he could build up the whole body. Scientific men are far more modest. A few years ago they found the better part of a battered human skull in Sussex, but they are disputing to this day how the missing parts of that skull ought to be filled in.

Now, of the early mammals we have only a few small bones in the rocks, and they would not tell us much by themselves. But you remember how we were able to describe, in the fourth chapter, the fishes which ten millions of years ago left the water and began to live on land. Remnants of that primitive family, the lung-fishes, still survive in nature. Animals of this kind are often called "living fossils." They help us even more than fossils do. No specimens of the earliest birds have survived in nature, and we should know very little about them if we had not been so lucky as to find the two fossil birds in Bavaria. But with the mammals it is quite different. Nature has preserved specimens of them alive for us.

We are fond of saying that nature "does" this or the other. Of course, it is literally true, as all the forces and causes or agencies that we know belong to nature. But even children ought to be warned against the practice of thinking that "nature" has intentions. Take, for instance, this preservation of the early mammals all through several millions of years. It

will give another glimpse into the machinery of nature if we describe it.

At the time when the earliest mammals appeared, towards the end of the Permian Ice Age, South Africa and Australia were, as we saw, connected by land. It was in that part of the world that the little early mammals lived. We find their bones in South Africa and their living representatives in Australia and New Guinea. They wandered from Africa to Australia; or, as is more probable, they were evolved on the lost continent, which is now beneath the waves of the Indian Ocean, and travelled east and west. Anyhow, they overran the country which we now call Australia. But during the Age of Reptiles the land between Africa and Australia foundered. One might almost say that, when the early mammals reached Australia, the gates were closed behind them. Australia became an island. So when, in the course of time, lions and tigers and other carnivorous mammals were evolved in the rest of the world, they could not reach Australia, and its very primitive population slumbered on until early man and his dog came along to disturb them.

That is why we find primitive mammals in Australia. The most primitive is a small furry creature, about the size of a rabbit, which is often called in English nature books the "Duckmole," because it has a beak something like the duck's and it burrows in the banks of the streams. Australians generally call it the Platypus, or, if they have been to Melbourne

or Sydney University, they call it the *Ornithorhyncus* ("Bird Nose"). In describing the life of the early mammals at the beginning of this chapter I described the Platypus. It makes a nest in its burrow, and lays eggs in the nest. When the young are born they lick the mother's breast, and they are nourished by the fat (milk) which oozes through the pores. So the Duckmole is a reptile is so far as it lays eggs, which no other mammal in the world does, but a true mammal because it suckles its young.

There is a very different animal of the same family, the Spiny Ant-Eater, in New Guinea; but we will pass on to the next stage. As everybody knows, the native animal population of Australia consists entirely of pouched animals like the kangaroo. There is a wild dog, or Dingo, that has puzzled naturalists a good deal; but on the whole it seems to have been introduced by early man, who must have been in Australia a quarter of a million years ago. The native population are kangaroos, wallabies, and other animals which are distinguished by the mother carrying her young in a pouch in front of her belly.

The reason for this peculiar arrangement is very interesting. Most people, even children, know that the young of one of the ordinary mammals—a kitten, puppy, whale, or human being—is formed in the mother's womb, and built up on her blood. Certain blood-vessels connect the little body in the womb with the mother's blood-vessels. The child is "blood

of her blood." The kangaroo mother has not got these blood-vessels. She cannot nourish the body of her young with her blood. She goes a step beyond the Platypus, it is true. She hatches the eggs *inside* her own body; but when they are hatched—when all the nourishment in the egg has been used up—she can do no more in her womb. The very tiny and imperfect young are born. Naturally, they would die if left to themselves. She takes them in her mouth, puts them in her pouch, and there they hang on to her breasts (which are low down) until they are fully formed.

Here is the next stage in the formation of a mammal; and we are much obliged to Australia for preserving these ancient curiosities for us. The higher mammals are so much more perfect in their arrangement for the birth of the young that these primitive mammals would not be able to stand competition with them. The waters of Australia kept them away. For science the Platypus and the kangaroo are extremely interesting; and there is a third type which is in some respects between the two. We do not say that they are the ancestors of the mammals, but they are precious remnants of the great family of early mammals of the Age of Reptiles, and they beautifully illustrate the evolution of the mammal body.

During the Age of Reptiles, as we saw, their higher organization was of no service, and they lived an obscure, hunted life and made little progress. Then

came the great chill of the Chalk period and the removal of the giant reptiles. The African branch of the family now began to go ahead, while the Australian branch remained nearly stationary (as isolated populations generally do). Towards the end of the Chalk Period, and in the next geological period, we find so rapid and rich an expansion of the mammals that it is impossible to give even a summary account of it here. We must be content with a simple outline.

As I said, we do not regard the living duckmole and kangaroo as ancestors of the mammals. The kangaroo (and pouched animals, or "Marsupials," generally) is clearly a side-line. The duckmole is a better specimen of an early ancestor, if you omit the "beak" and other features which were developed later. From something like the duckmole, at all events, a slightly higher type of mammal, building up its young in its womb, developed in Africa, and travelled north. These early mammals were probably "arboreal and insectivorous"; they lived in trees and fed on insects. When *their* Golden Age dawned they multiplied rapidly, and, as we have seen so often, soon experienced a heavy struggle for life, and evolved in different directions. From eating insects some developed a taste for larger game, and the familiar contest of the vegetarian and the carnivore set in.

The development of the carnivores can be very fairly traced by the rich fossil remains. Apart from the seals and walruses, which retired to the ocean

from the grim struggle on land, the carnivores are now mainly divided into a "dog" family and a "cat" family. We have the common ancestors of these, and can satisfactorily trace the evolution: the bears, dogs, wolves, foxes, otters, jackals, badgers, etc., on the one hand, and the lion, tiger, leopard, lynx, hyæna, mongoose, etc., on the other. In the early period we have carnivores with the general features of the various types in one body, and, slowly, in the course of two or three million years, the specific types are shaped. There were at an early date even fiercer carnivores than now. At one time there was a large lion-tiger (the "Sabre-Toothed Tiger," it is often called), with canine teeth, of terrible strength, seven or eight inches long.

These carnivores I take first because they help us to understand the rest of the mammal family. They proved to be the customary grisly machinery of natural selection. Largely in the attempt to get away from them, as well as to avoid competition for food, the rest of our mammals spread in all directions. Moles and rabbits found refuge underground. Hedgehogs and porcupines developed their barbed-wire entanglements. Squirrels remained in the trees and obtained their great agility. Shrews took to the streams; porpoises and whales to the sea. Some (lemurs, bats, etc.) adopted night life, instead of day life. Some of the carnivores did the same, and new and more wonderful devices had to be evolved.

The great order of the Ungulates (hoofed animals) spread over the four continents, and generally developed speed. The hippopotamus relied on bulk, and life in the water. The rhinoceros got bulk, a good coat of mail, and a horn. The elephant also had weight, a fair speed in case of need, and a pair of very formidable canine teeth (tusks). But the majority developed high speed and keen scent.

The ancestors of all these hoofed animals had five toes on each foot. We have numbers of remains of them; and there is a little animal in Africa to-day, the *Hyrax*, which goes back a long way towards them, as it had four toes on the front feet and three on the hind feet. But you have only to count the toes of your cat, and remember that carnivores and vegetarians had a common ancestor, to realize this. Running tends to reduce the number of toes. If you watch an athlete waiting for the pistol at the beginning of a race, you see how he stands "on tiptoe." In running the weight of the body is lifted as much as possible off the soles of the feet and thrown on the toes. And if the toes are like the human fingers, longer in the centre and shorter at the sides, the weight is thrown on the *central* toes, and the side toes disappear. The horse became in time a three-toed animal, as the rhinoceros is. But the ancestors of the rhinoceros stopped there, and developed bulk and armour. The ancestors of the horse continued to rely on flight, two further toes disappeared, and the

modern horse with one toe and one toe-nail (hoof) was born.

We can in the same way trace the evolution of most of the mammals. We have found the bones of the ancestors of the elephant for many generations, and can say how its trunk was developed. We find its canine teeth growing steadily longer. Perhaps they were used for digging succulent roots. The nose, to be of any use, had to keep pace with the teeth in length, and the chin grew out to the same length to bear the weight of the nose. When nose, teeth, and chin became about a foot long, the nose (or trunk) developed powerful muscles attaching it to the skull. The chin again retired—we trace all this in fossil elephants—and the elephant was left with two very long teeth and a very long nose.

In much the same way, we can trace the evolution of the camel, the bear, the seal, the dog, the cat, the pig, and so on. We can follow the development of all the bewildering varieties of teeth, of claws, of limbs, of hairy coats, of horns, of eyes, of noses, of breasts, etc. Food and safety are the keys to most of their structures. Sexual selection—the choice of a mate with certain features—explains other things: the smooth face of some monkeys, the lion's mane, and other features. Evolution is the great key. It puts together the jig-saw puzzle of nature as no other human thought ever did.

"Struggle" is only part of the mechanism. We

have to keep our eyes wide open in studying evolution, as there are numbers of different influences at work all the time. The changes of land and water continued. All through the time of the evolution of the mammals the land was rising. It made a great difference to many of them. Vegetation also, as we saw, was changing. The fruit-bearing trees were coming in, and there were presently immense stores of rich food, apart from insects, in the shape of nuts. Until carnivores learned to climb trees, this was a very safe and satisfactory world to live in. A very large family of the primitive insect-eating and tree-climbing mammals remained in the trees, and prospered. While the horse was developing on the plains of America, and the hippopotamus in the swamps of Africa, the monkey family was evolving in the trees, all unconscious of the remarkable destiny of one of its branches. Here we naturally open a new chapter.

CHAPTER X

THE ORIGIN OF MAN

MONKEYS have always had a strange fascination for men. More than one tribe that lived among them has puzzled over that queer suggestion of humanity which they seem to have, and declared that they must be human beings who had fallen from grace. By the end of the eighteenth century it was openly suggested in England that man had "descended" from an animal of the kind. There were jeers and jibes and howls of laughter everywhere. Learned men and unlearned scoffed. Now there is not a man of science in the world who does not admit man's descent from an ape-like form; and I do not think that there is now a bishop in the world who would oppose them. So let us not laugh too loudly at new ideas.

It is usual to explain very carefully that man has not been evolved from a monkey or an ape. Certainly no existing monkeys or apes are in the line of man's ancestry. There are in each case certain structural differences which forbid us to suppose it. The Dutch are not descended from either us or the Germans. They are related to us and the Germans through a

common ancestral tribe of some thousands of years ago. They are remote cousins of ours. So the living apes and monkeys are related to us only through a common ancestral tribe of three or four million years ago. They are remote cousins. Thoughtless people sometimes ask why we cannot turn a man-like ape into a man. They never ask whether we could turn a negro or a Red Indian into a white European. Yet the white and black and red men had a common ancestor probably less than quarter of a million years ago, whereas it is certainly much more than a million years, possibly two or three million years, since the common ancestor of the ape and the man lived.

The difficulty that some people still have in imagining the descent—it would be better to say "ascent"—of man from an ape-like form of long ago is caused by the foolish habit of contrasting *themselves* with a gorilla or an orang. There is about themselves a dignity, a wisdom, a virtue that are lamentably absent from the gorilla. But if, instead of taking that finished product of human evolution, ourselves, we adopt the more sensible course of taking a lower type of human being, the argument grows thinner. After all, it is not *we* who descended from an ape-like form; it is our remote ancestors. We descended from *them*. So let us get as near as we can to our ancestors. The Australian black takes us a long way. I have seen Australian aboriginal "ladies" who would not

be so very disdainful of an orang. Yet these are not half-way back to our ancestors. Some of the central African natives take us still further. Take the ugliest and most stupid of these that you can find, imagine something far more ugly and stupid, and then you have our human ancestor. We have various skulls of him, and we know it. He goes *very* near the higher ape-family.

But even we highly civilized and refined folk have in our bodies—some day, perhaps, scholars will say in our characters (wars, cruelties, etc.) also—many traces of our brute ancestry. Why has the male human being got breasts? He has real, though stunted, milk-glands behind those little warts or teats that you see. Why? Evolution alone gives the answer. We come of a very ancient group of animals, in which the male helped to suckle the young. Why have we those shrivelled pieces of cartilage which we call our ears? They have no functions. They do not help you to hear. Evolution, and evolution alone, answers the question. We come of a remote animal ancestor which had movable, pointed, useful ears like those of the horse. There are about a hundred organs, or parts or traces of organs, in the human body to-day that can be explained only in this way.

We come of a remote animal ancestor. What was it like, and how and why did it become man? I have said that it is now customary to explain very carefully that our ancestor was *not* a monkey or an ape. I con-

fess that I think this caution is overdone. It is a concession to the spiritual police. If we had the remains of man's ancestors before us, they would almost certainly be classed as those of monkeys in the earlier stage and apes in the later. Possibly some of them are actually among the existing fossils.

On this point, however, there is some dispute among men of science. There are those, possibly the majority, who would look for man's last pre-human ancestor in some branch of the family of large man-like apes which spread over the region of the Mediterranean between a half-million and a million years ago (to use a common scale). Certain branches of this family became the gibbons, gorillas, orangs, and chimpanzees. Other branches died out. One branch became the human race.

Other scientific men would place the departure from the ape-world much further back. Professor Keith one of the most recent authorities, thinks that the branch of the arboreal animals which was to become man separated from the main stem before the man-like apes were developed. He looks for a common ancestor of the primitive humans and the primitive apes something like two million years ago.[1] This common ancestor was, however, of a monkey-type, a branch of the very large simian world of the time. But a more recent writer has maintained that the

[1] See the excellent genealogical trees in his *Antiquity of Man* (1915), pp. 508 and 509.

whole family of lemurs, monkeys, and apes have such differences of structure from man that they must be regarded as separate developments. In other words, man has a very remote common ancestor, of three or four million years ago, *with* the lemurs, monkeys, and apes; but our ancestor never passed through any of those stages. These writers, of course, hold that man was evolved from a primitive mammal, but that his ancestors were not at any time so close to the monkeys as to run the risk of being classified with them.

I am only mentioning these theories for the information of the reader. The grounds of them do not seem to me convincing, and I will follow the usual view. This is, shortly, that a branch of the primitive insect-eating mammals remained in the trees after the Chalk Period, when most of the others descended upon the freer earth. They developed in the direction of the monkeys; whether through the lemur stage, or whether the lemurs are (as seems probable) a side-line, we need not inquire here. Two or three million years ago an enormous family of monkeys spread over Europe (as far north as central England), Asia, and Africa; and a branch passed into America. One section of this family became the man-like apes, and man's ancestors must have been so closely related to these apes that, if one were produced to-day, we would superficially pronounce it a man-like ape.

But how or why did our branch of the family get that increase of brain which was the beginning of

human development? Most people think that this is a very difficult question, because they have a very exaggerated idea of the increase of intelligence that was necessary. They never ask us how or why the man-like apes got *their* increase of intelligence over the ordinary monkeys. Yet it is probable that the earliest man did not surpass the chimpanzee in brain-power more than the chimpanzee surpassed the monkey. The earliest human skull that we have may be 400,000 or 500,000 years old. But man had then been developing for hundreds of thousands of years. Unless you suppose that he was strangely unprogressive during all that time, you are forced to recognize earlier stages in which his brain was not superior to that of a man-like ape; for the earliest man we know, the product of ages of evolution, is below the level of the lowest existing savage.

We will not, however, waste time on considerations of this kind. The scientific authorities of the world, belonging to the various branches of science which touch this question, have long been quite unanimous that man, body and mind, was evolved in this way. If there are any persons who like to call into question a statement on which all the scientific authorities in the world are agreed, I can only say that England is a free country; but I do not care to argue with such people. Man, with an ape-like body, got some slight increase of brain which natural selection began to foster. How did he get it?

It is generally agreed now among the experts that leaving the trees and beginning to live on the ground is enough to give our branch of the family an advantage. Of the four man-like apes three live to some extent on the ground, and some even use their hands to help them along. The fourth, the gibbon, is much more of an arboreal animal. It is very unlike man, and not particularly intelligent, but it may interest us here for two reasons: it can stand upright, and it is extraordinarily active in the trees. Of course, it is not in the line of our ancestry, but some of the best authorities think that man's ancestor was probably very active like the gibbon. If you have seen a gibbon in its cage at the Zoological Gardens, you must have noticed its prodigious leaps and untiring activity.

Now, it is supposed that our branch of the family quitted the trees. It has been suggested that perhaps our ancestors lived in forests in certain parts of Asia, and that, owing to the rise of the land and increasing dryness of the atmosphere, the forests disappeared. Many reasons could be imagined. In any case, you will have no difficulty in seeing that such a descent from the trees would sharpen the wit. On the ground a sharper watch must be kept for enemies. The hunt for food is more exacting than among nut and fruit-bearing trees. The back legs bear the weight of the body more and more. The hands are used more and more as hands. Physiologists work out the effect on the brain of all these changes, and they tell us that

the new life would stimulate the brain. If you allow at least half-a-million years to reach the level of the lowest savage from the level of the chimpanzee, you will realize that this suffices; and in spreading the progress over that long period you are assuming a rate of improvement of intelligence immeasurably slower than we have actually witnessed in the last hundred and fifty years.

It is really the slowness of man's early evolution that puzzles us. I have on an earlier page mentioned a prehistoric human skull that was found at Piltdown, in Sussex, in 1911. It must have been buried something like 400,000 years ago. There has been a great deal of controversy about this skull, as parts are missing, and it is possible, in reconstructing it, to make the forehead slope back like that of a gorilla or stand up like that of a modern man. From this single skull, therefore, we will not draw any firm conclusion. But the jaws were undoubtedly brutal and retreating, the teeth bulging; and the majority of the authorities concluded that it was the skull of a man very low down in the scale of intelligence. As all the other prehistoric skulls of early date are of the same character, we have a fair idea of our ancestor of between a quarter and half-a-million years ago.[1]

[1] This is questioned by Professor Keith and those who make the "Sussex man" highly developed in brain. They think that there were two human races at the time, a higher and a lower, and they put the real origin of man much further back, as I said.

And the stone implements, which we have recovered in millions, confirms this. Whatever dispute there may be about skulls, the stone implements tell a plain story of gradual evolution. They are at first so poor that experts could not agree for years whether they had been touched by the hand of man or whether their shape was purely accidental. These are called "Eoliths." The next and largest class of stone implements, those which belong to the Old Stone Age, begin with crudely chipped flints, and gradually pass, in the course of perhaps a quarter-of-a-million years, to rather skilfully shaped hand-axes, scrapers, chisels, etc. They seem to make it impossible for us to think that there were two races, a higher and a lower, half-a-million years ago. Indeed, only a few of the crudest flints (if any) go back to that remote period, yet man had then already been on the earth for ages. Thus from the stone implements we gather that for ages man was too low in intelligence even to shape stones for his use as tools and weapons. He probably used sticks. Then for further hundreds of thousands of years he was still too low to conceive the idea of making handles for his implements, or making the bow and arrow, and merely made such progress as a poor type of savage might in the shaping and finer touching of his stones. It is a story of most extraordinarily slow progress in intelligence.

Putting together the bones and the stones, we can fairly reconstruct the story of early man. For some

reason or other a branch of the ape-like tree-climbers, as active as gibbons but as intelligent as orangs, left the trees. The busier and more vigilant life on land sharpened their wit a little, and they entered upon the long, slow road of evolution of intelligence. They lived in small family groups, as the man-like apes do; not social groups. At first they may have helped themselves along with their knuckles, as gorillas do; but, if they were already as nearly erect as gibbons, they would be able to use the hands more and more for grasping purposes. Sticks would be their natural weapons; but throwing stones, and eventually hitting their enemy with large stones, would not be a very advanced step to take. Various kinds of monkeys do this. The human touch began when this primitive creature first knocked two flints together to give one of them a sharper edge. The age of "Eoliths" opened.

It seems probable that the cradle of the race was in the region of the south-west of Asia. A great deal of land foundered about that time in what is now the Indian Ocean. Probably the region of man's evolution was part of this lost continent, the last remnant of the continent which, we saw, at one time connected Asia with Africa and Australia. It is significant that we find our earliest human remains in the island of Java. In the collection of prehistoric remains at South Kensington you will find a skull marked the "Pithecanthropus," found in Java. The name means "Ape-Man," and the specimen is so labelled in every

collection in the world. It tells its own story. These bones belonged to a creature which was half ape and half man, or midway between the higher apes and the lowest savages. As a matter of fact, scientific men at first disputed very warmly whether they were the bones of an ape or a man. We now admit definitely that they are human, and that they do not even represent the earliest human phase. Man had already been evolving for hundreds of thousands of years. But, of course, the Java branch of the family have remained stationary, as isolated tribes do. The bones in that case really represent a much earlier phase of human evolution, and are most interesting. The thigh bones are curved, the teeth projecting, and the skull extremely low in the scale of intelligence.

We have a dozen skulls and jaws representing the next chief phase—man of the Old Stone Age. The Piltdown skull seems to belong to quite the earliest part of it, and is very valuable. Other skulls found in France, Belgium, and Germany show various stages in the long journey upward. Man was still, after half-a-million years development, below the level of the Australian black. The skull of an Australian black grimly watches me, in my study, as I write this. It is quite respectable in comparison with some of the prehistoric skulls I have examined. The man of the Old Stone Age had a low, retreating forehead, brutal jaws, and a robust but not tall frame. He wore no clothes, but had still a thick coat of hair

over most of his body. All his implements were carried and used in the hand, without handles, and he had no bow and arrow. He had no home. The climate was still so good that the rhinoceros and hippopotamus and elephant wandered over Britain with him. He lived in family groups, not social groups. He was still subject only to the very slow and cumbrous evolutionary method of natural selection—the struggle for food and life and survival of the fittest. Had he remained subject only to this law of progress, we might all to-day be at the level of the Zulu. But natural selection now took on its grimmest form, an Ice Age, and—something happened.

CHAPTER XI

SOCIAL EVOLUTION

LET us glance back for a moment at the course of our story. During the first half of it, which we crushed into a few pages, life had not got beyond the stage of the worm, the shell-fish, and the star-fish. Twenty, if not fifty, million years were used up in this poor advance. Let us, for the sake of being clear, give a definite number of years to the story of life—say, fifty million years, though it was probably much more. On that scale it took thirty million years for life to rise to the level of the fern, the beetle, and the fish. Seven or eight million years later life had advanced as far as the first reptile.

Then a great Ice Age occurred, and the primitive birds and mammals appeared. But there was a reaction, and for seven or eight further million years the reptile was the lord of the earth, and the mammal made hardly any progress. Forty-five million years out of the fifty million were over when the mammals began to spread. Four out of the five remaining million years were over before the very lowly and primitive thing that we can just call man came on the scene.

But the pace of progress was still very slow. For at least three quarters of a million years man made inconceivably slow advance. For most of the time he must have been stationary. Then the last Ice Age occurred, and we shall see that it drove men into social life. Dates are difficult, but we may put this development of social life, roundly, about fifty thousand years ago—to take the *end* of the Ice Age and the full term of its influence. Man now reached a level a little above that of the Eskimo. The pace was now much faster. Ten thousand years ago the foundation stones of civilization were laid in Egypt. Five thousand years ago two great civilizations had reached a high development. But there was still something wrong with the machinery of evolution. Man was nominally, but not thoroughly, social. There was no social sentiment between groups of men—tribes or nations—and horrible wars wasted their resources and destroyed their lives. Seven hundred years ago Europe was in most respects lower than civilization had been five thousand years before. A few centuries later the advance was resumed. A hundred years ago we had got back to the *general* level of ancient Rome and Greece. And in the last hundred years, which have been especially marked by the growth of social ideals, we have passed every previous high-water mark of civilization, and have made more progress than was made in any *five* hundred years in the history of man!

This is what some writers on science and social questions (like Mr. Benjamin Kidd) forget—or do not know. "Darwinian" progress, or progress by painful struggle and natural selection, is a great fact. But it is a description of the past, not an ideal of the present. It is the method of unintelligent nature, costly and slow. Darwin himself—a very gentle and humane man— drew a distinction between "natural" and "artificial" selection. Natural selection we have seen plenty of. Artificial selection is when man breeds new species of pigeons or dogs or sheep. It is intelligent, economical, and speedy. It has been greatly developed in our time, when new fruits and flowers are created speedily and cleanly, as Luther Burbank does in California. Darwin would, of course, have said, if you had asked him, that to set up "nature's" way (that is to say, remember, unintelligent nature's blind way) as a model for intelligent man would be the height of absurdity. But Darwin shrank very naturally from politics—all social work was "politics" or "Radicalism" in his time—and was concerned only with the past or with non-human nature. Darwinism has not the slightest bit of hostility to social idealism. It has nothing to do with it.

What Darwin did not know as well as we do to-day was the importance of social evolution. Dr. Russel Wallace tried to show this, but his work is rather confused. I pointed out as we went along that dur-

ing the overwhelmingly greater part of the story of life there was no social evolution at all. Social life was found only among sponges and corals and other unconscious or barely conscious types of animals, and they made no progress during millions of years. Social life proper began only in the last two or three million years. There is no proof, in fact, that it began earlier than within the last million years. At all events, beavers, bees, ants, etc., began their social ways in only quite recent geological time. So the "Darwinian factor" has been the chief agency of evolution during forty-eight out of fifty million years.

In Darwin's time very little was known about prehistoric man. Now we know his story very fairly. I have described the early part of it: a period of non-social life and extraordinarily slow progress. Curiously enough, many advanced social writers insist on regarding early man as social almost from the start. They probably think, that this explains his progress; and they would change their opinion, which is a pure theory, if they knew how very little progress man made for three-quarters-of-a-million years. The facts are all the other way. The man-like apes, early man's cousins, are not social. They live generally in families. The lowest living human groups to-day are imperfectly social. They live in family groups, with strict monogamy, and have no tribal organization. And, as far as we can gather

from the pre-historic remains, early man was not social, and did not live in groups until the Ice Age. So we may fairly infer that the clan or tribe, the social group, was formed by the clinging together of families, not the family evolved out of the social group; and that this occurred late.

Now, the geological record throws a very important light on this. During all that long period when early man was merely *creeping* upward, so to say, the climate of Europe was much warmer and better than it is to-day. At first it was like the climate of Algeria; later like the climate of Australia. Men had plenty of primitive food, and no need for fire, clothing, or houses. But it was again growing steadily colder. All the great mountain chains of our world were rising, and when they reached their culmination a great Ice Age set in. Five times in succession, with comparatively warm periods between, a sheet of ice and snow spread from the mountains over Europe and North America; and there were other sheets wherever there were high mountains. At the fourth and greatest spread of the ice-sheet Europe was glacial as far south as the Thames and the Danube, and America as far south as St.Louis and New York.

The pre-historic inhabitants of Europe were driven south, and forced to live in caves. No doubt rock shelters would be used at first, and men would gradually venture into the dark caverns. We find groups huddling in the caves of Derbyshire, and very large

groups living in the caverns of the south of France and the Pyrenees. We find that they now begin to make clothes out of skins. You can see in the British Museum to-day some of the bone needles they made and used. They learn how to strike fire from flint. They develop a skill in art; and towards the close of this "cave period" we find quite clever carvings in ivory (tusks of mammoth), and drawings on stone, bone, and ivory. In short, the pace of human progress was enormously quickened during the coldest period of the Ice Age, and it was virtually a new race that spread over Europe when the ice and snow disappeared.

Social evolution had begun. Families were forced to live together by the very nature of their new homes. This would lead to greater and greater efforts to communicate with each other. From the structure of the jaws of man before the Ice Age we can fairly gather that he had no articulate speech. Language of a crude kind seems to have been evolved in the caverns. Men could exchange ideas, to some extent; and the clash or contrast of different cultures is the great secret of human progress. "Struggle" is necessary. But those who think that it must be a struggle of weapons and muscles, or of greed and selfishness, are hopelessly unscientific. The struggle of ideas and ideals in a perfectly harmonious group is enough.

The main advantage of social life and communica-

tion is that it greatly helps the weaker in intellect to rise. The man of poor mind can share the ideas and discoveries of the genius. The race rises as a whole, so that after the Ice Age we are not surprised to find rapid progress. The stimulus to progress given by social life would be checked, as long as the hard conditions lasted, by the desperate struggle for food and warmth. The new increase of intelligence helped, because it created better weapons—the spear, bow and arrow, hafted axe, etc.—but the severity of the conditions would tend to distract and absorb energy. When the last ice-sheet had melted, and Europe recovered at least the degree of warmth it has to-day, the new race, the men of the New Stone Age, spread over it. In this the stimulus to progress was partly checked. Tribes lost all communication with others, and stagnated. Progress would be most in the south, where groups were nearer each other.

I am, of course, neglecting the greater part of the human family in this sketch. No doubt it had been distributed over the earth before the Ice Age, but it was chiefly the branch of the family which turned towards Europe that experienced the full stimulation of the Ice Age. During the greatest extension of the ice-sheet this branch of the race would, to a large extent, retreat south, across the land bridges to North Africa and Asia minor. There would be a relatively thick population from the Persian Gulf to Algeria, and this would be thickest from the Persian

Gulf to Egypt, where there was most depth of country. Just about this time the valley of the Nile and the valley which we call Mesopotamia were formed by the rivers; and out of the turmoil and struggle of tribes for the fertile valleys came the first beginnings of civilization.

The story of evolution is a great aid to correct thinking. It may begin with stars which are a long way off, but it leads to man and man's evolution. It gives you a solid scientific ground for hope and trust in man. No evolutionist can be a pessimist. The human story is only just opening. Those million years of early human development, of which I have spoken, were only the prelude. Now we know more or less where we are and what we are doing. According to the best estimates of mathematicians, man will remain on this earth for something more than ten million years yet. At the rate at which we have gone for the last hundred years, this period of time opens out a prospect of such happy developments as are beyond the capacity of the liveliest imagination. *We* are the factors of evolution to-day. We are the masters and the creators. Let us get the plan right and forge ahead.

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What Is Man?

By

J. Arthur Thomson, M.A., LL.D.

Professor of Natural History, University of Aberdeen
Editor of "The Outline of Science"

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